JOURNAL

JOURNAL

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CONTROL ENGINEERING

THE RANGE OF PRACTICAL FORMS OF AUTOmatic control is extremely wide and runs the whole gamut of signal strengths dealt with in electrical engineering from the score of electrons required to be detected by an electrometer valve to the control of the output of large turbo-alternators interconnected by the national Grid. It is a boast of men engaged in control engineering that 'if a quantity can be measured, we can control it' whether the medium used is electricity, a fluid or a gas. This boast is empty at the larger end of the scale, for one can certainly record the extent of tides but no man as yet can do much about controlling them. However at the smaller end it makes sense and is a challenge to those concerned with measurement to do so with increased refinement and accuracy. To this extent the two operations of measuring and controlling make progress together. This lies behind the recent decision to change the title of the former Measurements Section of The Institution, thus acknowledging the maturity of this old-established engineering art, for so long little understood, and now one of the most interesting fields of activity for engineers.

One of the earliest studies of this subject was made by Maxwell on the stability of speed-governed steam engines. It was written during his early retirement at a time when the dynamics of rigid-body systems was being formulated. This was before he went to the Cavendish, and began thinking about the novel subject of electricity. The boot is now on the other foot, for while the understanding of electricity has been far advanced and consolidated this is not true of control engineering. It is only in the last twenty years that a clear recognition of the common principles involved in a diversity of control and regulating mechanisms has been made. This recognition was precipitated by the seemingly unrelated solution of a stability problem in telephone repeater amplifiers. The feedback amplifiers used for this purpose do not resemble the usual control system but there is a direct analogy between the two, since both are closed-sequence systems involving power gain around the loop. The full implications of the new understanding of control systems have yet to be realized. Many new applications of the principle of closed-sequence control are being made (not always in the most efficient way), so that to-day a large part of engineering effort in this country is directed towards developments in which control plays a central part.

We have all heard a good deal recently about automatic production, or automation. For a general discussion of some of the technical and social effects of this we can do no better than re-read the admirable Address by the Chairman of the Measurement and Control Section, which was published in the January issue of the *Proceedings*. Automation consists essentially of three modifications of current manufacturing technique: the incorporation of automatic handling, the development of automatic assembly and the use of automatic checking facilities. For the electrical engineer there is an opportunity here for the development of ingenious apparatus for controlling such automatic processes and perhaps more particularly for their co-ordination. The result of these changes is to convert normal batch production into an almost entirely automatic flow production. Under conditions of full employment such as we have now it is almost inevitable that something of this sort will be found necessary, for it represents a method of increasing productivity without increasing the number of people involved. Already such a trend is a familiar feature of our daily lives and is in essence no more revolutionary than the replacement of point-duty policemen by traffic lights. In the long run it does mean that some jobs will change, but in a way that could make them more dignified and congenial. Perhaps the real point is the speed with which these changes can be made. While it is not difficult to say what could be done now in the light of existing techniques, it is much more difficult to say what will be feasible in the future, for this requires both foresight and insight into possible advances. It is doubtful whether some of the prophets who have made exciting forecasts of control-system developments possess such sagacity, and almost certainly the changes foreseen will in fact be neither so sudden nor so immediately far-reaching as they have suggested. Certainly we must hope that the extravagant descriptions of the future of control-system engineering will not prejudice valuable research by men who are already at grips with the real problems. It would be unfortunate if such able men were discouraged from this work by a process of dilution which often follows the over-dramatizing of scientific development.

THE NEW SUPPLEMENTAL CHARTER

Approval by the Queen of the Changes in the Royal Charter

At a Special General Meeting of Corporate Members and Associates held on the 23rd June, 1955, the drafts of a Petition for a Supplemental Charter and of the Supplemental Charter itself, which had been prepared by the Council, were approved for submission to the Privy Council. Her Majesty the Queen has now been graciously pleased, by and with the advice of the Privy Council, to approve the Petition and to grant a Supplemental Charter in substantially the same terms as in the draft submitted by The Institution, and the text of this approved form is given below. It is followed by a short report of the Special General Meeting, at which last year's President, Mr. J. Eccles, gave a simple introduction to the four clauses of the Supplemental Charter that amplify, clarify or amend the original Charter. As many members will remember, an explanatory memorandum from the Council about the Supplemental Charter was circulated with the notice convening the meeting in June, 1955.

ELIZABETH THE SECOND

by the Grace of God of the United Kingdom of Great Britain and Northern Ireland and of Our other Realms and Territories Queen, Head of the Commonwealth, Defender of the Faith.

TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING!

WHEREAS Our Royal Predecessor King George the Fifth in the year of our Lord One thousand nine hundred and twenty-one by Royal Charter dated the fifteenth day of August in the twelfth year of His Reign constituted the persons then members of the Association or Institution incorporated under the Companies Acts, 1862 and 1867, and known as 'The Institution of Electrical Engineers' and all such persons as might thereafter become members of the body corporate thereby constituted pursuant to or by virtue of the powers thereby granted and their successors a body corporate and politic by the name of 'The Institution of Electrical Engineers' with perpetual succession and with power to use a Common Seal and to implead and to be impleaded by the same name:

AND WHEREAS by the said Royal Charter (hereinafter referred to as 'the Original Charter') it was (by Article 4 thereof) provided that the objects and purposes for which The Institution of Electrical Engineers (hereinafter called 'The Institution') was thereby constituted were to promote the general advancement of Electrical Science and Engineering and their applications and to facilitate the exchange of information and ideas on those subjects amongst the members of The Institution and otherwise and for that purpose:

(*a*) To hold meetings of The Institution for reading and discussing communications bearing upon Electrical Science and Engineering, or the applications thereof, or upon subjects relating thereto.

(*b*) To hold or promote Exhibitions of instruments, apparatus, machinery or other appliances connected with Electrical Science and Engineering, or their applications.

(*c*) To print, publish, sell, lend or distribute the proceedings or reports of The Institution, or any papers, communications, works or treatises on Electrical Science and Engineering or their applications, or subjects connected therewith, in the English or any foreign tongue, or any abstracts thereof, or extracts therefrom.

(*d*) To take charge of the books, pamphlets, publications and manuscripts known as the Ronalds Library, which are the subject of a Deed of Trust dated Twenty fourth June, One thousand eight hundred and seventy-five, and to observe and perform the trusts of the said Deed, and to add to the said Ronalds Library, and form, acquire, receive, hold and take charge of any supplemental or additional library of books, works or manuscripts on Electrical Science and Engineering, or the applications thereof, or other subjects allied thereto.

(*e*) To make grants of money, books, apparatus, or otherwise for the purpose of promoting invention and research in Electrical Science and Engineering, or their applications, or in subjects connected therewith:

AND WHEREAS by the Original Charter it was also provided that no member should have any personal claim on any property of The Institution and no part of the income or property of The Institution should be paid or transferred directly or indirectly by way of dividend or bonus or other-

wise howsoever by way of profit to the members of The Institution except in the case of and as a salaried Officer of the Institution:

AND WHEREAS Our Royal Predecessor King George the Sixth in the year of Our Lord One thousand nine hundred and forty-six by Royal Charter dated the nineteenth day of November in the tenth year of His Reign (which said Charter is hereinafter referred to as 'the Charter of 1946') licenced, authorized and forever thereafter enabled The Institution or any person or persons on its behalf (and that notwithstanding the Original Charter) to acquire for the purposes of The Institution any lands, tenements or hereditaments or any interest therein within His United Kingdom of Great Britain and Northern Ireland not exceeding in the whole (with any lands acquired pursuant to or by virtue of the powers granted by the Original Charter) the annual value of fifty thousand pounds and made other ancillary provisions:

AND WHEREAS doubts have arisen as to whether The Institution is empowered fully to promote and pursue the general objects and purposes for which The Institution was by the Original Charter expressed to be constituted as set out in Article 4 thereof without any limitation or restriction having regard to the fact that such article after setting forth such general objects and purposes sets forth certain specific powers being the specific powers which are set out in (*a*) (*b*) (*c*) (*d*) and (*e*) of the second recital to this Our Supplemental Charter:

AND WHEREAS it has been represented to Us that it is expedient that The Institution should be empowered to remunerate any member of The Institution for services rendered to The Institution whether as a salaried Officer of The Institution or as a servant of The Institution or otherwise howsoever and to pay interest on money lent to The Institution by any such member or rent for premises let by any such member to The Institution and to give to any such member prizes (whether in cash or otherwise) and scholarships and exhibitions:

AND WHEREAS it has been represented to Us that it has for many years been the practice of many of the Corporate Members of The Institution to describe themselves as Chartered Electrical Engineers as is provided by the Bye-laws of The Institution and that it would be for the benefit of The Institution and of the status of Electrical Engineering generally that the Corporate Members of The Institution should be expressly authorized by Royal Charter so to describe themselves:

AND WHEREAS neither the said Original Charter nor the Charter of 1946 contains any provision empowering The Institution to alter, amend or add to the same or either of them and it has been represented to Us that it would be much for the benefit of The Institution that it should with suitable safeguards be so empowered:

NOW KNOW YE that We of Our Royal Will and Pleasure and moved thereto by Our desire to promote the efficiency of The Institution for Ourselves, Our Heirs and Successors in addition to and notwithstanding anything contained in the Original Charter have been graciously pleased to grant, ordain and declare and by these Presents Do grant, ordain and declare as follows:

1. The general objects and purposes for which The Institution was by the Original Charter constituted as set out in Article 4 thereof namely to promote the general advancement of Electrical Science and Engineering and their applications and to facilitate the exchange of information and ideas on those subjects amongst the members of The Institution and otherwise shall not be deemed to be in anywise limited or restricted by the specific powers thereafter specifically set out in such Article 4 and The Institution may promote and pursue such general objects and purposes and each and every one of them in as full and ample a manner as if no such specific powers as are hereinbefore in this Article referred to had been specifically set out in such Article 4 (but without prejudice to the power of The Institution to exercise such specific powers and each and every one of them) and may do all things incidental or conducive to the attainment of such general objects or purposes or any of them.

2. Nothing in the Original Charter or elsewhere contained shall prevent

(i) the payment by The Institution in good faith of reasonable and proper remuneration to any member of The Institution as an Officer or servant of The Institution or to any such member in return for any services rendered to The Institution;
(ii) the payment by The Institution of interest at a rate not exceeding five per centum per annum on money lent to The Institution by any such member or reasonable and proper rent for premises demised or let by any such member to The Institution; or
(iii) the giving by The Institution to any such member of prizes whether in cash or otherwise and scholarships and exhibitions;

and The Institution shall have power to make all such payments and gifts as aforesaid.

3. A Corporate Member of The Institution shall be entitled to the use of the style or title of Chartered Electrical Engineer for so long as he shall be a Corporate Member.

4. The Council of The Institution may by a resolution in that behalf passed at any meeting of such Council by a majority of not less than two-thirds of the members of such Council present and voting (being an absolute majority of the whole number of the members of such Council entitled to vote at meetings thereof) and confirmed at a Special General Meeting of Corporate Members of The Institution held not less than one month nor more than four months afterwards by a majority of not less than two-thirds of the Corporate Members present in person or by proxy and voting alter, amend or add to the Original Charter, the Charter of 1946 and this Our Supplemental Charter or any of such Charters and any such alteration, amendment or addition shall when allowed by Us, Our Heirs or Successors in Council become effectual so that the Original Charter, the Charter of 1946 and this Our Supplemental Charter as the case may be shall thenceforward continue and operate as though it had been originally granted and made accordingly. This provision shall apply to the said Original Charter, the Charter of 1946 and this Our Supplemental Charter as altered, amended or added to in manner aforesaid.

IN WITNESS whereof We have caused these Our Letters to be made Patent.

WITNESS Ourself at Westminster the fifth day of March in the fifth year of Our Reign.

BY WARRANT under the Queen's Sign Manual.

COLDSTREAM.

THE NEW SUPPLEMENTAL CHARTER *(contd.)*

THE SPECIAL GENERAL MEETING OF THE 23rd JUNE, 1955

Mr. J. Eccles, President, took the chair at 5.15 p.m.

The President said that the meeting was a Special General Meeting of Corporate Members and Associates of The Institution, and he asked the Secretary to read the notice convening the meeting.

After the Secretary had done this the President requested all those Members who had not signed the attendance book to do so.

He said that the purpose of this meeting had been explained in the documents which were before the members, but he would give a brief recapitulation of the reasons for the proposed changes in the Royal Charter.

Clause 1 of the proposed Supplemental Charter established beyond question the reading of Clause 4 of the original Charter, which Counsel's opinion had supported, namely that the specific activities set out in this clause were written in only by way of example and not in order to limit the manner in which members pursue the objects of promoting the general advancement of electrical science and engineering and their applications.

The intention of Clause 2 was self-evident. Here again it was intended to remove any doubt such as might be occasioned by decisions of the courts on the interpretation of words similar to those incorporated in 1921 in the original Charter.

The right which would be granted when the proposed Clause 3 became operative would represent a clear-cut ruling that those who were Corporate Members of The Institution might describe themselves as 'Chartered Electrical Engineers'; it would remove the difference which at present existed between the Bye-laws prescribing this designation and the original Charter, which spoke of the designation as 'Member of the Chartered Institution of Electrical Engineers'.

Clause 4 was in the nature of a machinery clause and under proper safeguards it would enable changes to the Royal Charter to be introduced on the initiative of the Council and with the support and approval of members, subject only to an allowance by the Lords of Her Majesty's Privy Council. This would represent a less ponderous procedure than that involved in seeking the grant of a Supplemental Charter when any change appeared desirable.

Mr. Eccles next commended the changes to the approval of the meeting and formally moved the following resolution:

> That the draft of a Humble Petition of The Institution of Electrical Engineers to the Queen's Most Excellent Majesty in Council praying for the grant to The Institution of a Supplemental Charter and the draft of the proposed Supplemental Charter by such Petition prayed for (both of which drafts have been produced to this meeting and for the purposes of identification subscribed by the Chairman thereof) be and the same are hereby approved and that the Council of The Institution be authorized to cause the Seal of The Institution to be affixed to the said Petition.

Dr. P. Dunsheath seconded the resolution.

There being no other speakers, the President put the resolution to the meeting and it was carried unanimously.

A Discussion Meeting

USE OF OVERLOAD CAPACITY

A Supply Section discussion on the 'Co-ordination of Overload Capacity', which was opened by Mr. H. G. Bell, was held at Savoy Place on the 25th January, 1956.

MR. BELL started his remarks by saying that electrical equipment designed to carry a continuous load with a specified temperature rise under stated conditions of ambient temperature may, under actual conditions of service, be capable of carrying loads in excess of the normal rating without harmful effects. If the load is cyclic a higher maximum value may be permissible.

Since the overload capacity of items of plant depends upon the heat capacity of the equipment concerned it will be different for switchgear, cables, transformers, etc. Load cycles also vary widely according to the type of circuit and the locality, and they may change with time in individual instances.

By utilizing overload capacity it is possible to postpone capital expenditure on reinforcement, but this additional capacity is not obtained free of cost. Generally speaking, utilization of overload capacity is associated with increased losses and also with increased voltage drop. These factors may be so important, particularly where plant is frequently operated beyond its rated load, that it is sometimes a definite economic advantage to underload plant. There are, however, other cases where it pays to take full advantage of overload capacity. An example is a block of load supplied by a pair of feeders which share the load for most of the time. Should one circuit be out of commission occasionally, it is obviously an advantage if the second circuit has sufficient overload capacity to carry the whole of the load, even though it is at the expense of some loss of efficiency.

Few equipments consist of one unit only, and a limited overload capacity of one component may restrict the use of overload capacity of several other components. In the example of transmission and sub-transmission circuits a unit may comprise switchgear, cables, transformers and overhead lines, and these equipments differ widely in their overload capacity. Moreover, the standard sizes of equipment have been adopted on arbitrary bases and there is little relation between them. For instance, the standard sizes of busbars are given in amperes, of cables in square inches of cross-section, of transformers in kilovolt-amperes and of switchgear in amperes.

Regarding transformers, some guidance on permissible overload conditions is given in B.S. 171 : 1936. The 'Loading Guide for Transformers up to 10 MVA with Type ON Cooling', prepared by the Central Electricity Authority, gives further guidance and makes it easy to determine the permissible loading for various values of ambient temperature on the assumption that the form of daily load cycle will not differ materially from certain typical curves which are shown. The American Standards Association have published a loading guide which includes a method of converting actual load cycles into thermally equivalent base loads and peak loads.

Mr. Bell stated that the safe loading of cables has been the subject of much valuable work by the Electrical Research Association and the Cable Makers' Association, who have issued tables giving the safe working temperatures, continuous loadings and intermittent loadings for a comprehensive range of paper- and cambric-insulated cables. It is difficult to generalize about the overload capacity of cables because so many factors are involved and each case requires consideration on its merits.

Overhead lines of the sizes commonly used in distribution practice are so well cooled that the thermal rating is much in excess of the economic rating. There is therefore normally ample margin for temporary increase of loading (subject to voltage drop), especially in winter when the ambient temperature is well below the design figure.

It is not the practice to assign an overload rating to any switchgear manufactured to British Standards. If the ambient temperature conditions are more onerous than the basic figures, the current rating must be reduced. Owing to the low thermal capacity of switchgear, as compared with transformers and buried cables, the parts which are subject to heating attain their working temperatures relatively quickly, and any cyclic rating which could be assigned to the gear would be of little practical value.

There are, however, instances where the design of contact parts is determined by short-circuit considerations, and this gives some margin above the normal current rating. If more information on this subject could be made available by the switchgear manufacturers it might help in avoiding unnecessary expenditure and in permitting limited capital to be spent in a more useful way. In the meantime it is necessary to choose switchgear with a current rating equal to the maximum load to be carried by associated plant and cables.

General Discussion

The discussion, in which thirteen speakers participated, dealt mainly with the behaviour of individual pieces of equipment. More than one speaker questioned the traditional expressions for the effect of temperature on insulation. There was also agreement that higher loadings were possible at low ambient temperatures, as, for example, with distribution transformers during the winter season.

In other circumstances, the operation of transformers at only 85% load might be economically sound, as it saved the expense of a standby transformer by taking 130% load in an emergency. Persistent overloading was recognized as being bad economically, and a speaker pointed out the equally false economy of apparatus designed to show an apparently gratuitous overload capacity. In addition to inhibited oils, the possible use of non-inflammable coolants in transformers was mentioned, with the observation that the temperatures thus made feasible might correspond to prohibitive iron and copper losses.

Reference was made to operating practice in America; the plant factor in New York, stated to be 45%, was considered inferior to British figures, and was thought to account for the apparent American disregard of the top oil temperatures in their transformers. There was a suggestion that British specifications might usefully adopt an annual average figure for ambient temperature. Another speaker showed that cables on American 110-volt systems, being lightly rated because of the sensitivity of such systems to voltage drop, offered a greater overload capacity than ours.

Cyclic distribution loads were discussed, including the dependence of overload capacity upon the preceding level of loading and the thermal capacity of the plant. For buried cables, the heat conductivity of the soil, the number of cables in proximity and the possible deterioration of cables through handling were mentioned as variables which were worth consideration in the joint studies being made by the C.E.A. and C.M.A. with a view to establishing rating factors for cyclic loads. A speaker added, as a guide to the overload capacity of a combination of underground cables with transformers, that the thermal time-constant of the latter might be three hours, against some ten minutes for unarmoured cables, or fifty minutes for armoured types. This speaker observed that Kelvin's law for determining cross-sectional area ignored charges such as the cost of installation.

Changes in turbo-alternator rating practice were outlined, showing how mutual support by interconnected stations permitted full-load operation at the continuous maximum rating without any overload capacity on individual machines. Over-design gives adventitious margins but these dwindle as design experience accumulates. It was noted that under these modern operating conditions, overload capacity in the station transformer is superfluous. The possibility of matching the overload capacity of the turbine to that of its alternator was questioned because of the discrepancy between mechanical failure and electrical deterioration.

It was recognized that the overload capacity of switchgear was limited by the small and diverse heat capacities of the parts, so that overload ratings could not be predicted or specified with confidence. In general, the discussion suggested that agreement on the choice of standard ambient temperatures and a wider knowledge of the heating characteristics of different equipment would facilitate co-ordination.

An Electrical Engineering Review

AUTOMOBILE IGNITION SYSTEMS

The internal-combustion engine, like many modern inventions, is a meeting ground of various sciences and technologies. This review describes, in elementary terms, the basic electrical requirements of ignition systems and the latest engineering practice used in their manufacture, with examples of typical present-day ignition equipment. The author is in the Engineering and Design Department of Joseph Lucas Limited.

By A. N. PARTRIDGE

THE automobile petrol engine derives its power from the burning and consequent expansion of a mixture of petrol vapour and air under compression. The function of the ignition apparatus is to produce high-voltage sparks at the electrodes of the sparking plugs located in each cylinder, combustion of the fuel-air mixture being initiated by virtue of the spark temperature.

In a four-stroke engine, half the number of cylinders fire for each engine revolution. Thus, in a four-cylinder engine running at 3 000 r.p.m. (a very modest requirement with modern automobile engines) each cylinder fires 25 times per second, so that the ignition equipment is called upon to produce 100 sparks each second at this speed. Moreover, for reasons of engine performance and fuel economy, each spark must be timed relative to its successor and to the crankshaft position with an accuracy of the order of one seven-thousandth of a second—and a means is required of advancing or retarding the spark timing with variations of engine speed and load.

The voltage necessary to produce the spark in the cylinder depends upon the gap between the sparking-plug electrodes and the compression ratio of the engine, varying from 5 kV to 15 kV or sometimes even higher; while the energy required to cause the onset of combustion in the least inflammable mixtures is of the order of 0·01 joule.

Types of Ignition System

The requirements set out above are achieved in the modern petrol engine by either of two methods:

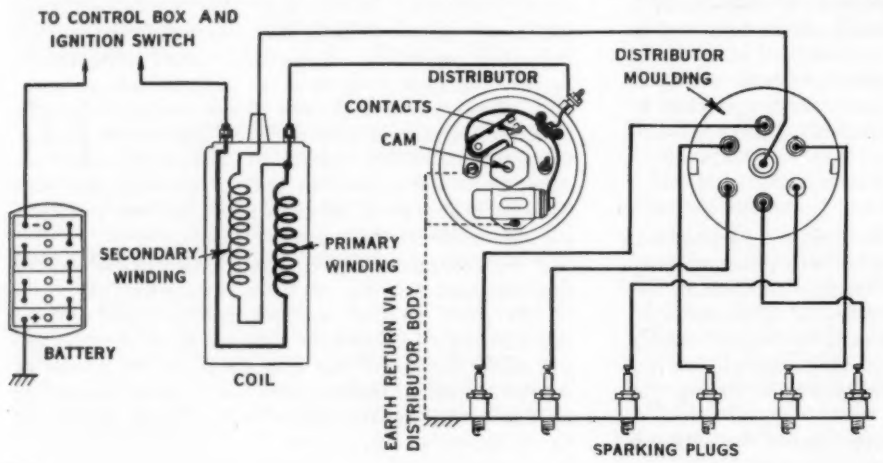
(*a*) a battery–coil system, or
(*b*) a magneto, operating independently of an external electrical source.

For a considerable time, the former has been the universal fitting on all passenger cars, most petrol-engined commercial vehicles and a number of motor cycles; this system, and typical modern coil apparatus, will therefore be described in some detail.

Use of the magneto is nowadays confined to some motor cycles, agricultural machinery, engines for industrial purposes, certain racing cars, and similar special applications.

The Battery–Coil Ignition System

The electrical connections of this system are shown in Fig. 1 and its essential components are:

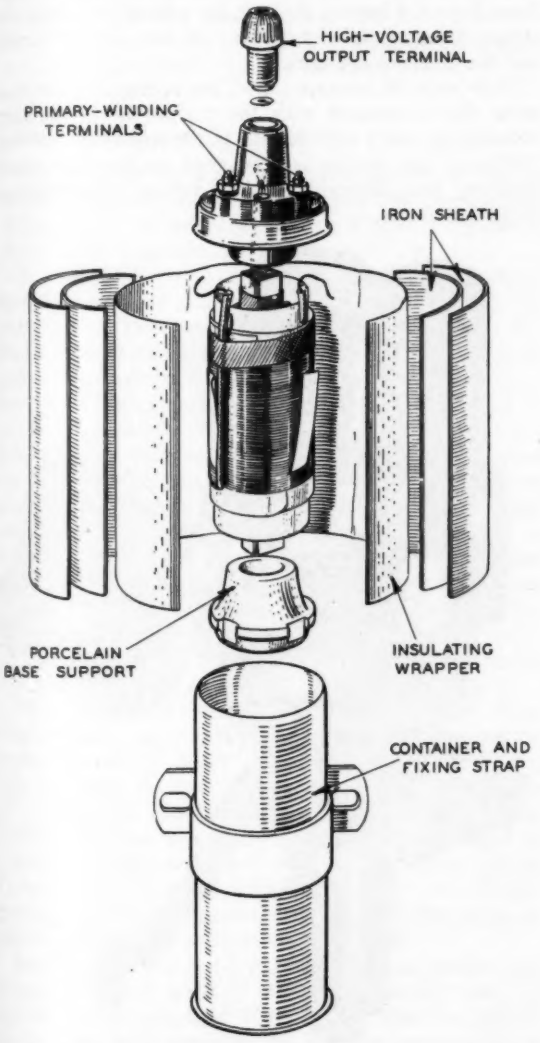


1 *Circuit diagram of a coil ignition system*

(*a*) the battery,
(*b*) the ignition coil, which transforms the battery voltage of 6 or 12 volts into the high voltage necessary to cause a spark at the plug gaps,
(*c*) the contact-breaker, which is driven by the engine and controls the flow of current through the primary winding of the ignition coil,
(*d*) the high-voltage distributor, which, as its name implies, distributes the high voltage from the ignition coil to the appropriate sparking plug,
(*e*) the mechanisms whereby spark timing is varied automatically to meet the exact requirements of engine speed and load, and
(*f*) the sparking plugs.

The Ignition Coil

Fig. 2 shows the component parts of a typical coil. A laminated iron core carries two windings, the secondary innermost and over this the primary. A typical secondary winding comprises 18 000–20 000 turns of 44 s.w.g. enamel-covered copper wire in thirty layers, each insulated from the next by paper. A corresponding 12-volt primary winding may consist of some 360 turns of 25½ s.w.g. enamel-covered wire in three layers, with varnished-paper interlayer insulation, such a winding having a resistance of about 4½ ohms.



2 *Component parts of an ignition coil*

The core and windings are placed within an iron sheath, and the complete assembly is housed in a sealed container filled with an insulating compound. In the past, common practice was to use an impregnant of high-melting-point wax, and to hold the coil assembly in position by pitch run into the container after assembly. More recent practice is to use oil impregnation, with the winding held in place mechanically. Technically there is little to choose between the two methods, but the latter gives slightly better heat dissipation and lends itself more readily to mechanization of the assembly process.

Low- and high-voltage connections are brought out to terminals in the cover moulding.

As indicated in the circuit diagram (Fig. 1), an auto-transformer connection is employed, the starting end of the secondary winding being connected to the finishing end of the primary winding. Most modern coils are wound to give negative polarity at the high-voltage terminal, and hence to produce what is termed a negative spark at the plug.

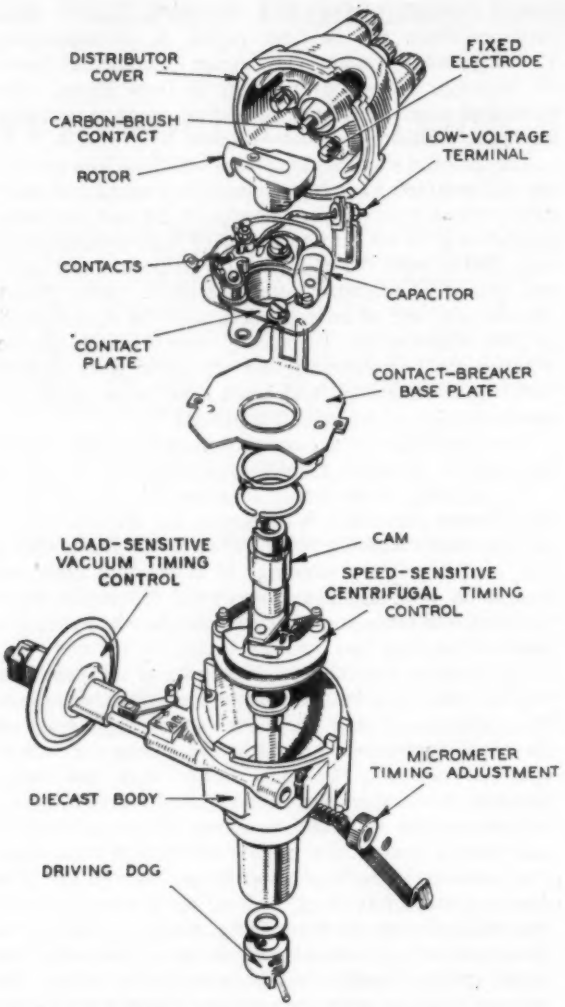
The reasons for this (to digress for a moment) are twofold. First, it is known that the breakdown voltage of the sparking-plug gap decreases as the temperature of the negative electrode increases; thus, since the central electrode normally becomes hotter than the outer electrode, from which heat is conducted away readily, it is advantageous to make the central electrode negative and thereby reduce the breakdown voltage. Secondly, the positive electrode of a spark gap is affected to a greater extent by burning, and so, by making the outer electrode of the sparking plug positive, burning is distributed over its considerably larger surface area. The same applies equally to the distributor, where the burning is spread over the stationary electrodes instead of being concentrated on the rotor arm.

The Distributor

The contact-breaker and high-voltage distributor, together with the automatic timing-control mechanisms described later, form a combined unit usually called simply the distributor.

Reference to Figs. 3 and 4 (p. 274) will help in understanding the design of a typical modern unit for 4-cylinder engines. The body is a diecasting, with a steel shank bored to accommodate a long oil-impregnated bearing bush, in which runs the hardened-steel driving shaft. The upper end of this shaft drives a hardened-steel cam having four lobes, while the lower end is coupled to a half-engine-speed drive by means of a dog clutch, arranged off-centre to prevent incorrect assembly.

The contact-breaker comprises two tungsten contacts, one mounted on a pivoted lever and the other on an



3 *Exploded view of a modern distributor unit*

adjustable bracket screwed to the contact-breaker plate. The pivoted lever is attached to a spring which tends to hold the contacts closed. Integral with the pivoted lever is a Bakelized-fabric heel which is actuated by the lobes of the cam when the latter rotates, causing the contacts to separate against spring tension each time the heel is lifted.

A condenser of about $0{\cdot}2\,\mu$F capacitance is connected directly across the contacts to reduce sparking on separation. On modern distributors this condenser is often of the self-healing metallized-paper type, as compared with the paper-and-foil type in extensive general use up to a few years ago.

High-voltage distribution is achieved by means of a moulded rotor attached to the driving shaft above the cam. A brass electrode on this rotor is connected electrically to the ignition coil by a rubbing carbon-brush contact, while fixed electrodes in the cover moulding are connected to the sparking plugs by means of rubber-covered high-voltage cables. As the shaft rotates, the rotor electrode passes very close to the fixed electrodes. It is arranged that at the instant when the high voltage is induced in the coil (that is, when the contacts are separated), the rotor electrode is adjacent to the appropriate stationary electrode, and a high-voltage spark jumps the small gap to effect distribution.

Mode of Operation

When the ignition is switched on and the engine is cranked by means of the starter motor, the distributor shaft rotates and causes the contact-breaker to close and open alternately. When the contacts are closed, current flows from the battery through the primary winding, the circuit being completed by way of the contact-breaker and the frame of the vehicle.

Each time the contacts open, the collapse of the magnetic field associated with the current in the primary winding induces a high voltage in the secondary winding, which at that instant is connected to the appropriate sparking plug through the high-voltage distributor as explained above.

4 *Construction of a typical four-cylinder distributor unit*

In detail, the secondary circuit has associated with it a natural capacitance (of the plug, cable and outer portion of the secondary winding) which in effect forms a capacitor of about 50 $\mu\mu$F connected across the plug electrodes. As the voltage is induced in the secondary winding, this capacitor becomes charged, until such time as the plug-gap breakdown voltage is attained, when the stored energy is discharged across the gap. This produces what is known as the *capacitance component* of the spark, carrying an instantaneous current of 50 amp or more, and usually lasting for not more than one microsec. This is followed by the *inductance component* of the spark, consisting of magnetically stored energy, which is released comparatively slowly, and may last a millisec or more, with a current of the order of 50 mA. Under normal running conditions, it is the capacitance component which is resposible for the onset of combustion.

Shortly after the spark occurs, the contact-breaker closes, and the cycle of operations is repeated for a spark to occur in the cylinder next in the firing order.

Contact-Breaker and Cam Design

The profile of the cam, in conjunction with the design of the contact-breaker, will determine the *closed* period of the system, i.e. the period during which energy can be stored in the magnetic field of the coil.

In a 4-cylinder unit of the type described, the closed period is equivalent to about 60° of cam rotation, the open period in consequence being equivalent to 30°. For a modern coil system of standard design, the minimum closed period for a satisfactory spark is approximately 2 millisec, so that an engine speed of 10 000 r.p.m. could theoretically be attained without misfiring—assuming that the contact-breaker actuating heel followed the cam faithfully. In practice this is difficult to achieve at high speed without employing excessive spring loading, and the whole art of contact-breaker design lies in striking a satisfactory compromise between the mass and strength of the moving parts, the spring loading and the cam contour. A gently rising and falling cam, which would make possible a reduction in spring loading, meets its limitation in the large variation in ignition timing which would follow a small change in gap setting.

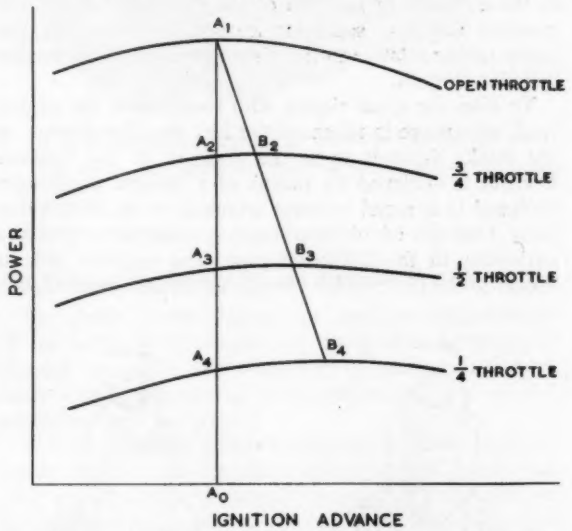
With careful design it is possible to satisfy these requirements on single-lever contact-breakers up to engine speeds of 6000 r.p.m. on both four- and six-cylinder units. At one time considerable use was made of double-lever contact-breakers for six- and eight-cylinder engines, but these are nowadays confined to engines working at abnormally high rotation speeds. In these units the work is divided between two contact-breakers operating alternately, so that each has twice the effective time in which to perform its cycle.

Setting of the contact-breaker gap affects ignition performance in two ways. If the gap is greater than the specified width (usually 0·015 inch) the closed period will be reduced, with detriment to ignition performance at high engine speeds, and also the instant of ignition will be advanced, since contact separation will occur too soon. On the other hand, if the gap is too small, the spark timing will be delayed, thus again affecting engine performance.

Additionally, it can be shown that the rate of contact separation (determined by the cam profile) and the setting of the contact-breaker gap play a large part in determining the degree of contact wear through transference of tungsten from one contact to the other.

Alteration of the Spark Timing

The flame propagation starts very quickly after the heat of the spark has been developed, but the flame takes a relatively appreciable time to spread completely through



5 *Curves showing variation of engine power with ignition advance*

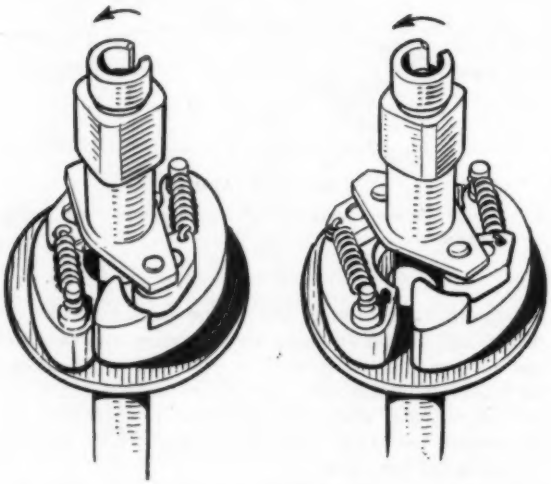
the combustion chamber. As engine speed increases, the piston will obviously move an increasing amount while the mixture is burning; thus, in order for combustion to be completed soon after the piston reaches the top of its compression stroke (a necessity for optimum performance), the spark must occur progressively earlier as engine speed increases.

Further, the rate of flame propagation is affected by the density of the mixture in the cylinder, being greatest at fully open throttle when the density is highest. Thus, for a given engine speed, the less the throttle, the slower the combustion, and the greater the distance travelled by the piston while the combustion is taking place. To compensate for this the ignition should be advanced as the throttle is closed. This is clear from Fig. 5, which shows the variation of engine power with ignition advance for different throttle settings. The 'speed-conscious' control operates for maximum power at fully open throttle (whatever the speed), as shown by the line A_0A_1, and

will not, of itself, give maximum power at part-throttle settings, which can be obtained only by some additional advance to the points B_2, B_3 and B_4.

To satisfy the speed requirement, a centrifugally-operated mechanism is housed in the body of the distributor unit beneath the contact-breaker, and acts as a governor which alters the position of the cam relative to the driving shaft. In its most common form, this mechanism comprises two pivoted weights which move outwards under the influence of centrifugal force as engine speed increases. Movement of the weights is controlled by the tension of two springs, the characteristics of which determine the rate and degree of ignition advance. The cam foot is linked to these weights, so that their outward movement causes the cam to turn in the direction of rotation of the distributor shaft; the contacts are thus separated earlier, so advancing the spark timing relative to the piston position in the engine cylinder (Fig. 6).

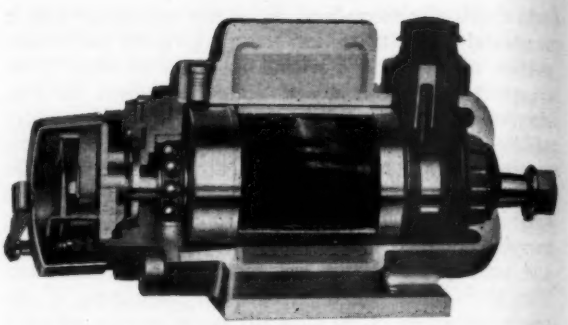
To alter the spark timing with variation in the engine load, advantage is taken of the fact that the suction in the intake depends upon the position of the throttle. Control is achieved by means of a flexible diaphragm enclosed in a metal housing attached to the distributor body. One side of this diaphragm is subjected to pressure variations in the induction pipe. The opposite side is linked to the plate which carries the contact-breaker, this



6 *Operation of the speed-conscious timing control*

As the weights move outwards under the influence of centrifugal force, the cam is advanced in the direction of rotation, thus advancing the instant of contact separation.

plate being capable of rotation within limits. Consequently, as the pressure varies, the diaphragm is deflected (against the tension of a control spring) and its movement causes rotation of the contact-breaker plate, thereby changing the position of the contact-breaker actuating



7 *A typical rotating-armature magneto for motor-cycle use*

The magnet and laminated field system are cast integrally with the body. Connection of secondary voltage to sparking plug is through the slip ring and carbon brush.

heel in relation to the cam and causing variation in ignition timing.

Connection to the vacuum control unit is not normally made to the manifold itself, but to a point in the carburettor adjacent to the butterfly valve, slightly on the atmospheric side when the valve is in its closed position. When the engine is idling and the throttle nearly closed, there is practically no vacuum; thus the diaphragm control does not affect the ignition timing. Small opening of the throttle brings the tapping onto the engine side of the butterfly valve, the degree of vacuum is increased and the timing is advanced. This continues up to a maximum advance at a throttle opening corresponding to about one-quarter full load, after which further valve opening causes a decrease in vacuum and the ignition timing is retarded accordingly.

A further timing control fitted to many distributors is a manually-operated micrometer control by means of which fine adjustments to the static ignition timing can be made easily to allow for changes in fuel and the state of carbonization of the engine. This control is linked to the load-conscious control just described, movement of the knurled adjusting nut causing rotation of the contact-breaker plate in the same manner.

Magneto Ignition

Magnetos in current use fall into two main groups—rotating-armature machines (Fig. 7) in which primary and secondary windings are carried on an engine-driven rotating core in the field of a stationary permanent magnet, and rotating-magnet types (Fig. 8) in which the magnet forms the rotor, the windings being carried on one limb of a laminated-iron circuit. The performance of these two types is identical, but the rotating-magnet design makes for a more robust construction.

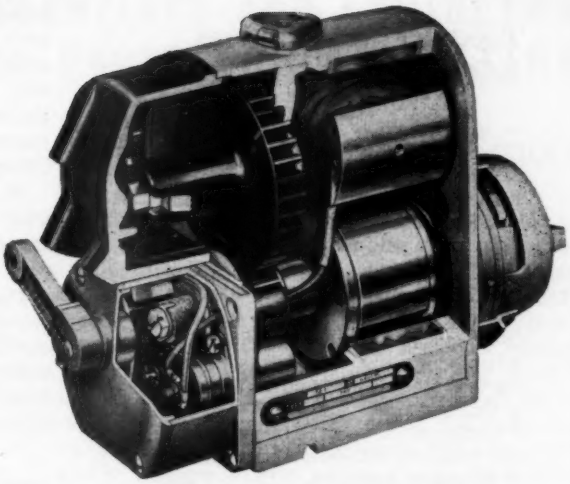
The principle of operation of the magneto is similar to that of the coil system, namely the induction of a high voltage in the secondary winding, but the method by which it is achieved is rather different. Reference to Fig. 9 will assist in following the sequence of events in a

magneto. As the armature rotates, voltages are induced in both primary and secondary windings. Current flowing in the primary winding (through a closed cam-operated contact-breaker) opposes any change of the magnetic field through the laminated core, and in effect distorts the flux due to the permanent magnet. At a predetermined instant, the contact-breaker in the primary circuit is arranged to open, so removing the constraining influence of the primary current, and the consequent rapid reversal of the magnetic field linked with the secondary winding causes a high voltage to be induced in it. This high voltage is applied to the sparking plugs by means of a high-voltage distributor similar to that used in the battery–coil system. Such a design will obviously produce two complete flux reversals per revolution of the armature. By suitable choice of driving speeds and distributor gear ratios, it can be adapted to suit normal engines of any number of cylinders.

Alternate positive and negative sparks are produced from the magneto (except in the case of certain single-cylinder units in which one spark is suppressed per revolution of the rotor). This follows from the fact that in the magneto the magnetic field is reversed in direction through the winding core, whereas in the battery–coil system the flux collapses to zero and then builds up again in the same direction.

Some magnetos incorporate a centrifugally-operated timing-control mechanism similar to that described for coil systems, the mechanism being interposed between the engine driving shaft and the magneto rotor. Other magnetos are fitted with a manual timing control which either changes the position of the cam with respect to the contact-breaker or vice versa, depending on the type of machine.

To improve low-speed performance of the magneto—particularly important if the engine has to be started by hand—an impulse coupling is often employed between engine drive and magneto rotor. When the engine is turned, a pawl prevents movement of the magneto rotor, whilst a spring within the coupling is wound up. At a certain instant the pawl is tripped and, under the influence of the unwinding spring, the rotor is turned rapidly through the sparking position, resulting in a high-energy retarded spark. Centrifugal force holds the pawl out of engagement above a speed of about 120 r.p.m.



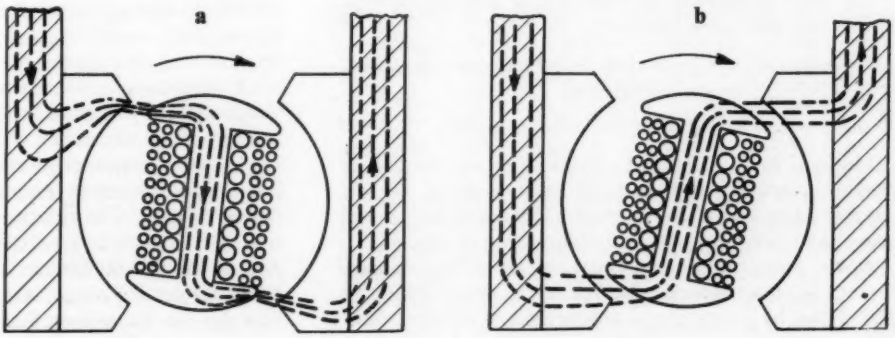
8 *A rotating-magnet magneto for four-cylinder engines*
This device has impulse coupling and manual control of ignition timing.

The Relative Merits of Coil and Magneto Systems

The ability of the magneto to function independently of the battery—the reason for its general adoption in pioneer motoring days—became of secondary importance with the successful development of more reliable generators and batteries.

The fundamental difference between the two systems lies in the fact that the spark-energy output of the coil system decreases with increasing speed, whereas that of the magneto increases, i.e. the output of the coil system is high when starting the engine, while the output of the magneto is then low. From the point of view of ignition performance, however, either equipment can be designed to deal adequately with any application yet encountered.

The really important advantages of the coil system are found in the small amount of power required to drive the cam spindle, and the fact that the cam spindle can be driven at camshaft speed. This low speed means freedom from noise, while the low power and moment of inertia



9 *Operation of the magneto*
(*a*) Flux path immediately before contact separation, showing how the field is distorted by the primary current.
(*b*) Flux path an instant after the contacts have opened, showing a complete reversal of flux.

Electrical Installations in Caravans

A second edition of The Institution's 'Recommended Practice for Electrical Installation in Caravans' has recently been published. The Recommendations deal in particular with connection of the electricity supply and with earthing. The installation of an earth-leakage circuit-breaker in every caravan is recommended, and the text of a notice 'Instructions for Electricity Supply' is given, which, it is suggested, should be fixed near the main switch, to give advice to the user.

Copies of the publication are obtainable from the Secretary, The Institution of Electrical Engineers, 2 Savoy Place, London, W.C.2, price 1s. 3d. post free.

mean that it is possible to fit a light, simple speed-conscious timing-control mechanism, and also that the vacuum-operated load-conscious control can readily be incorporated. These advantages, combined with weight and economic considerations, have led to the adoption of the coil system on all automobiles, with rare and specialized exceptions.

Sparking Plugs

Sparking plugs differ in detail design and construction to meet the varying conditions under which they operate. Essentially, however, all consist of a metal body, usually of rustproof steel, the lower end of which is threaded to enable the plug to be screwed into the engine block. Contained within this body is an insulator, through the centre of which runs the electrode, carrying a terminal at its upper end for connection to the distributor by high-voltage cable. The lower end of the electrode is arranged to give a small air-gap between itself and the earthed body the spark occurring at that point.

The chief functional requirements of a sparking plug can be summarized as follows:

(*a*) insulation of good electrical properties, high mechanical strength and resistance to thermal shock,
(*b*) reasonable life, and
(*c*) freedom from through-leakage of combustion gases.

Modern plug insulators are almost exclusively of sintered alumina, this material best meeting all the requirements. It has the necessary characteristics in (*a*) above, and is virtually inert to combustion products.

Apart from accidental breakage or other damage caused by mishandling, the life of a plug should be determined by the erosion characteristics of the electrodes, during which period the insulation should be free from fracture and should maintain its insulation resistance at a sufficiently high level to prevent electrical leakage to earth. The electrodes used in modern automobile sparking plugs are of nickel alloy with small additions of manganese, silicon and sometimes chromium. For special-purpose plugs, where extra-long life is an essential requirement, platinum (generally alloyed with small amounts of tungsten or iridium) is used.

Any leakage of combustion gas, between either the central electrode and the insulator, or the insulator and the body, will cause the temperature of the sparking plug to rise rapidly beyond safe limits, leading to ultimate disintegration and probable damage to the engine. Fused glass, cement and compressed powder are commonly used for the sealing of the central electrode in the insulator, while the seal between the outer surface of the insulator and the body is generally a soft metal washer—copper, cupro-nickel, phosphor-bronze and mild steel all being currently employed.

Ignition Interference Suppression

One allied aspect of the ignition problem should perhaps be mentioned in this brief review. Automobile ignition systems can seriously interfere with the reception of high-frequency radio signals, even when the receiver is located some distance from the interfering source. Consequently legislation has been introduced requiring vehicle manufacturers to ensure that the ignition systems of all new vehicles are suppressed to an extent limiting interference to a specified value.

The source of the interference (which is radiated from the high-voltage cables) is the exceedingly rapid rise and decay of current as each spark discharge occurs, which may be followed by a succession of such surges of diminishing amplitude. The remedy adopted is the insertion of resistors of the order of 10000 ohms in the high-voltage circuit to damp down this initial oscillatory current. The number of resistors necessary to ensure compliance with the standard laid down varies for different vehicles. Often only one resistor positioned at the distributor cover in the coil-to-distributor high-voltage cable may be adequate, but sometimes it may be necessary to provide additional resistors at each distributor high-voltage outlet and at each sparking plug. Resistive leads are sometimes employed instead of individual resistors.

Many modern distributors are provided with a measure of inbuilt suppression which may prove wholly adequate. The carbon brush, used to connect the high-voltage coil-to-distributor feed to the rotor arm of the distributor, is of composite construction, the resistive component being tipped by softer carbon to avoid wear of the rotating metal electrode.

The recommended practice for suppression of radio interference caused by motor vehicles is the subject of a British Standards Institution publication (CP 1001 : 1947), while B.S. 833 : 1953 gives details of the permissible interference limits, and the ratings and certain other requirements for general components used in making up suppression devices for automobile ignition systems.

THE RECRUITMENT OF SCIENTISTS AND ENGINEERS BY THE ENGINEERING INDUSTRY

A Discussion of the Zuckerman Report

In 1946, the Barlow Committee reported on scientific manpower. Following the recommendations of that report, universities set out to double their previous output of scientists and technologists. This increase was achieved by 1950 but the demand continues unabated. There is urgent need for further increases in the output of trained scientists and technologists.

Recently a Committee of the Advisory Council on Scientific Policy, under the Chairmanship of Professor (now Sir Solly) Zuckerman, examined problems of the recruitment of graduates and apprentices to the engineering industry and their Report was published in November, 1955.* Their examination covered a large sample of manufacturing and other industries requiring engineering graduates and apprentices and, among other things, they considered the effect on industry of the rapid expansion in the science and engineering faculties of universities. This expansion has been in the most part achieved by existing universities where technology already flourishes and not, as on the Continent and in the United States, by the creation of technological institutions. (Since the date of the Zuckerman Report, there has been, of course, the publication in February, 1956, of the Government White Paper on 'Technical Education', setting out the Government's plans of colleges for advanced technology, but these are not specifically discussed here.

The differential expansion of university faculties of science and technology compared with the humanities raises problems for university authorities. For the nation it does not produce sufficient scientists and technologists but, on the other hand, a view expressed by some industrial firms is that the expansion has gone too far by diverting to the universities a number of able boys who would otherwise have been available to industry for training as student apprentices. This view is not generally held by industry, which finds that the present output of graduates is entirely insufficient for present-day requirements. It does, however, emphasize the varying needs and attitudes of different sections of industry; some firms appreciate the need for diversion of the best talent to the universities in order to increase the output of engineering graduates—some, at the other end of the scale, neither yet want the university-trained scientist/engineer, nor indeed have much call for student apprentices. This will have to change if these firms and British industry are to maintain their present competitive positions.

The firms which were asked for information and views represented quite 50% of the total intake to industry of engineering graduates from universities (976 and, in addition, an intake of 70 graduates in subjects other than engineering, as well as 293 holders of National Diplomas). The total number of graduates recruited by these firms was about 25% below the number required. The firms which the Committee approached represent the leading firms and it was considered that the deficiency of 25% in the number of graduates recruited may well be an underestimate for the country as a whole. This deficiency was largely due to insufficient applicants, but some firms referred to the poor calibre of some of the graduates. There was, of course, the complaint of increased competition from rival organizations, and a complaint from some of the heavy electrical and mechanical engineering firms that too few graduates came to heavy electrical engineering, since men tended to be attracted by such subjects as electronics, aero engines, guided missiles, etc.

The complaint of poor calibre of some of the graduates is serious. There is a fairly widespread feeling that the quality of graduates has suffered from the rapid post-war expansion of the universities, resulting in some boys of lower academic ability becoming graduates, and in a smaller proportion living 'in hall', thereby losing some of the broadening influence of university life. The Committee agree that this is a problem, but they found no real evidence that the intellectual ability of graduates has in fact declined since the war. The impression that there is a lack of first-class ability among the new recruits to industry may be due to an expanding economy in a period of full employment.

The quantity of graduates must be increased, and the quality must be maintained—quality in the sense of the personal characteristics of leadership and initiative as well as academic attainment: as the Report says, 'While university training is not a necessary condition for the emergence of the former qualities, we consider that they are more likely to develop in the atmosphere of a university, where the student has an opportunity of rubbing shoulders with people whose interests lie in other fields.'

Quality is in fact stressed throughout the Report. To maintain the quality of engineering graduates, regard must be paid to the quality of the entrants to the university, and as long as engineering enjoys a lower prestige than other professions in many schools of standing, it will be difficult for engineering to attract its fair share of the available talent. Industry has responsibilities here—to present engineering as an attractive career, and to make the needs and views of industry more clearly known to the schools and universities.

The majority of firms prefer graduates to enter industry

* Report on the Recruitment of Scientists and Engineers by the Engineering Industry. (H.M.S.O. Price 1s. 3d.)

with a first degree, and then to receive practical training for two years. Higher degrees and post-graduate work in universities are generally regarded as more suitable for men intending to specialize in research, while post-graduate research in the universities is often said to conflict with the urgent needs of industry for technologists.

Graduate training and student apprenticeship schemes are both important in the engineering industry and are complementary rather than in competition. A number of firms commented on the fact that boys with qualities of leadership and initiative tend to come from middle-class homes with a long tradition of responsibility, and who have been unable to go to the universities because of family financial limitations: as one firm put it—'Student Apprenticeship in the modern context implied that industry pays for the development of the young man who rapidly becomes self-supporting instead of continuing from Public School to University as a charge on his father.' There is however a difference in view on the results of graduate training and student apprenticeship: the graduate apprentice has had a better chance of developing his capacity for analytical thinking, whereas the student apprentice, through the 'rough and tumble' of industrial life, tends to gain earlier an appreciation of industrial technique and requirements. By the age of thirty the difference between the two types of men is diminishing.

Both forms of training have their place and require expansion, avoiding on the one hand the 'creaming off' of all the talent to the universities and, on the other hand, over-emphasis of the danger of reducing the stream of student apprentices. In addition to these two streams, however, there is the need for the development of the industry-based sandwich scheme: for example, six months in each year full-time in a technological college and six months full time in the works as complementary parts of an integrated scheme of education and training.

The Committee conclude that the fear of some firms that an increase in numbers of university graduates will rob industry of student apprentices is not the view of the engineering industry as a whole; that industry requires good graduates and the universities cannot yet produce enough; and that even with further expansion of the universities there will still be sufficient talent in the country to provide all the good apprentices industry needs. But much remains to be done in order to attract the talented boys into the engineering industry, and to obtain more good graduate engineers. 'Only the strongest measures will prevent the present gap between supply and demand becoming greater than it already is.'

This was the Report—given above in abbreviated form and with inadequate detail—which was discussed at an Ordinary Meeting of The Institution on the 1st March, 1956. Sir Solly Zuckerman, Chairman of the Committee, gave an introduction to the Report and he was followed in the discussion by two other members of his Committee, Sir Frederick Brundrett and Sir Harold Roxbee Cox, as well as by Mr. A. S. Quartermain of The Institution of Civil Engineers, Sir Hamish McLaren, and Messrs. B. L. Metcalf, C. T. Melling, D. B. Welbourn, L. W. Phillips and S. E. Goodall. The President, who was himself a member of the Barlow Committee on scientific manpower, gave from the chair a brief summing-up of the discussion.

The Report was considered to be an excellent assessment of the problem facing the engineering industries, but the problem is not merely the present shortage but that which is likely to be faced in five and ten years' time as industry and technology expand. Sir Solly Zuckerman said that the Scientific Manpower Committee felt it would be useful to know more about what the demand was likely to be in five or ten years' time and that they would welcome any assistance The Institution could give in this respect. It is, moreover, a Commonwealth shortage and a world shortage. The shortage of graduates and student apprentices is not only in manufacturing industry. Consulting engineers, nationalized industries and engineering contractors all need more and all have attractive careers to offer. There is an urgent need to increase the number of graduates, particularly at the present time when the numbers in university age group are relatively low, but although the present 'bulge' in the age group in the schools should help to increase the number of graduates in five years' time, it is insufficient to close the gap and, moreover, expanding needs will demand an even larger number of graduates. Unless this can be achieved there will be grave danger to the country. We are not now training in Great Britain that proportion of each age group which is training in the engineering sciences in other countries. A larger percentage of the talent in the schools must be attracted to engineering—not in any selfish spirit which would rob professions such as medicine—but through the broader appreciation by certain schools with a non-scientific outlook that in this technological age a boy can find a rewarding career in engineering, not only in the material sense but through the satisfaction of service to the nation and to his fellow men and one, moreover, which requires and provides a widening avenue of educational attainment. Indeed, one of the immediate problems of the engineering industries is to convince those who are still doubtful, that an engineer with a broad knowledge of other subjects may be a man of greater education than one who lives in a specialized section of the humanities, but with his mind closed to the advancement of science and technology.

How, then, can more boys be attracted to engineering? The Institution's film *The Inquiring Mind*, vacation courses for schoolboys in the senior forms, school visits to engineering works, and—to influence the schools—conferences with headmasters and careers masters, were all mentioned.

Better teaching of science is important too. At present the facilities for teaching science in many schools are behind the times, and many boys tend to select other subjects as providing a more certain way of entering a university.

In the training of engineers, many problems arise. How can we as a nation expect to increase the quantity and quality of entrants to the engineering industry if we do not correct the deficiency in the number of science teachers at schools and colleges? How can we improve the quality if we concentrate too much on vocational knowledge and too little on the education of the whole man? How can we in this technological age secure a proper balance between liberal education and scientific knowledge? And, as advice to a university graduate, should a doctor's degree be taken before or after graduate apprenticeship? Or, how can we provide a ladder of possible promotion, where every apprentice has a real opportunity of promotion to the limit of his individual capacity? It is unfortunate that in this country the engineer has lost ground to the non-technologist in the realm of management; in America this has not happened.

Clearly we must maintain the status of the engineering profession as a means of improving the quantity and quality of entrants. But in our long-term plans we must go much further. There is adequate talent among the eleven-plus age group entering the grammar schools but too few boys and girls are staying long enough at school to take advanced courses. The Report on 'Early Leaving', referred to in the Zuckerman Report, states, '. . . in addition to about 10000 boys and 7000 girls who took advanced sixth-form courses, there were about 5000 boys and 5000 girls who had a capacity to do so if they had stayed longer at school. Of these, about 2900 boys and 1300 girls would have been suited for courses in mathematics and science. . . .'

The problem of improving the recruitment of scientists and engineers by the engineering industry requires the close attention of the engineering profession. But, more than that, it is a broad national problem, not of sectional interest but requiring co-operation between sociologists, educationalists, industry and the professional institutions.

C. T. M.

The Herbert Report on the Electricity Supply Industry

This note on the recent Report of the Committee of Inquiry into the Electricity Supply Industry is included primarily for the benefit of oversea readers whose attention has not yet been directed towards the content of this important Report. Not all of the recommendations of the Committee are mentioned in this note, which gives emphasis to those affecting organization and management.

On the 9th April, 1954, a Departmental Committee was appointed with the following terms of reference: 'To inquire into the organization and efficiency of the electricity supply industry in England and Wales in the light of its working under the Electricity Act, 1947, and to make recommendations.' The Committee was composed of seven members under the chairmanship of Sir Edward Herbert. It consisted of, *inter alia*, an accountant, a trade unionist, an industrialist, and an educationalist. The Report,* published in January, is a lengthy one of over 150 pages, with 125 main sections and recommendations.

The Report states early on that it would be quite wrong to call the industry inefficient; nor can the organization which has produced the results it has produced be described as a bad organization. 'It has made substantial technical advances and it has succeeded in supplying electricity to consumers at a price which on the average is only 30 per cent above that ruling in 1939. This has been done at a time when the cost of coal, the principal raw material of the industry, has increased by 270 per cent and the general cost of living index has risen by 137 per cent.'

The formal structure of the industry is criticized as not now being conducive to the highest efficiency; nor is the industry thought to have solved the right degree of delegation within the formal framework. It is emphasized that the industry has a long way to go in the introduction of modern aids to management, in budgeting, in work study, in operational research and in incentive wage schemes. It is suggested that the industry must take very energetic steps to ensure that it attracts and retains an adequate supply of first-rate talent for both technical and managerial posts. Management training, selective training and posting must be undertaken if the industry is to provide a future top management of the requisite calibre from within its own ranks.

The Committee felt that the determination of the national interest is the business of the Government and it is not for the industry to embark, in the supposed national interest, on any course other than a purely economic one unless so instructed by the Minister, subject to his responsibility to Parliament. The industry should be run as a purely commercial concern. The Central Authority should be divorced from the responsibility for generation, including the construction and operation of power stations, the Grid, and the Super-Grid. A new statutory corporation, the Central Electricity Generation Board, ought to be set up to undertake these duties and responsibilities. The reconstituted Central Authority would thus become the policy-making and general supervisory body over all the Boards. It is suggested that there should be only one management level below that of Area Board Headquarters and the number of Districts should be increased to perhaps 15 or 20 in each area. The Chairman of an Area Board should be freed from executive responsibility, which would be exercised by a chief executive appointed by the Board. It is stressed that the top salaries in the industry are low and this has the effect of depressing salaries at middle and lower management levels. The Committee therefore recommended considerable increases of salaries to bring them more into line with comparable positions in industry.

The Committee made a number of technical recommendations, e.g. that much more research should be carried on in all branches, including utilization research.

All in all it can be said that this Report puts considerable emphasis on management and management techniques. It is stimulating reading and the ideas behind many of the conclusions expressed are applicable over a wide range of industry, not necessarily nationalized.

* Report of the Committee of Inquiry into the Electricity Supply Industry. (H.M.S.O. 6s. 6d.)

A REVIEW *of the Proceedings, Parts A and B*

SHORT REVIEWS OF PAPERS

On the following pages are some brief articles based on, and written by the authors of, current Institution papers (including Graduate and Student Section papers). The authors have been asked to make these articles, so far as possible, of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

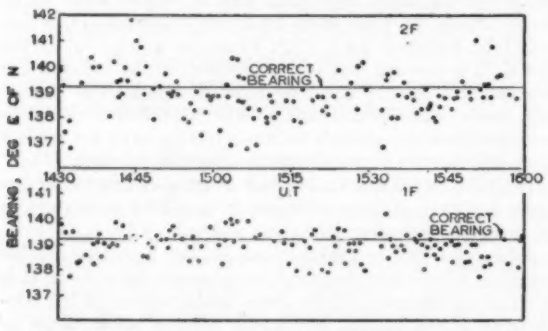
Ionospheric Reflection of H.F. Waves

A short review of a Radio and Telecommunication Section paper (No. 2011) entitled 'Directional Observations on H.F. Transmissions over 2 100 km', by E. N. Bramley, M.Sc., Ph.D. The paper is published this month in Part B of the Proceedings.

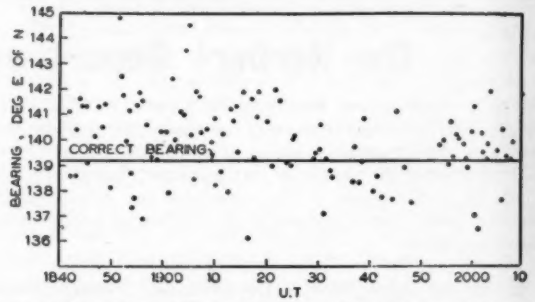
WHEN A HIGH-FREQUENCY RADIO WAVE IS RECEIVED AT the ground after reflection by the ionosphere its direction of arrival is found to fluctuate, owing to the existence of ionospheric irregularities which change with time. In general, for a distant transmitter, a number of modes of propagation can exist, and these can be investigated separately as discrete echoes, by the use of pulsed transmissions. It is then found that the echoes show variations of bearing with time about the true great-circle direction.

Previous measurements at distances of up to 700 km showed that the most important irregularities in the F layer of the ionosphere are in the form of large-scale wrinkles in the surfaces of constant ionization density, the undulations occurring in all horizontal directions. The effective tilts are generally about 1° or 2° in magnitude, and the period of the variations is of the order of 20 min.

The present measurements were made (with the same wide-aperture direction-finder as previously used) to test the applicability of these results at the greater distance of 2 100 km, and for this purpose pulse transmissions from Malta were employed. At this distance, geometrical considerations indicate that the bearing deviations caused by the ionospheric tilts would be much smaller than at 700 km, and this was in fact found to be the case. Fig. 1 gives an example of the results obtained in the day-time on a frequency of 11 Mc/s. Individual 'snap' bearings taken on the first and second order F echoes (1F and 2F) are shown, and it is seen that for both echoes



1 1F and 2F bearings on 11 Mc/s, 28th October, 1953



2 5 Mc/s bearings, first main echo, 19th January, 1954
200–300 microsec from start of echo pattern.

the average measured bearing is close to the correct value (139·2° E. of N.). The fluctuations about the mean are within about ±1° for the 1F and ±2° for the 2F echoes.

The results as a whole show that extremely high bearing accuracy is possible at this range, particularly for the 1F echo. For this echo, individual bearings had a standard deviation of only 0·8° about the grand mean, which was itself within 0·2° of the correct bearing.

The results shown in Fig. 1 indicate a mixture of 'slow' and 'rapid' variations, as found at shorter distances, but here it is difficult to separate them. Five-minute mean values were taken as an indication of the slower variations, due to the ionospheric tilts, and their magnitude was approximately that expected from the previous measurements. The more rapid (second-to-second) fluctuations were rather larger than expected, and this appears to be partly due to the fact that the pulse patterns were more complex than at the shorter distance of transmission, so that splitting and wave-interference effects were more pronounced. This was especially true for observations made at night on a

frequency of 5 Mc/s. A long train of overlapping echoes, extending over a time of 2–4 millisec, was generally observed, and there were often no discrete pulses which retained their identity for more than a few minutes, owing to the continual fading and mixing of the components. An example of the bearings obtained under these conditions is given in Fig. 2, and shows much larger variations in bearing than on 11 Mc/s. The grand mean of all the observations on 5 Mc/s was, however, within 0·1° of the correct value.

The directional results were unaffected by ionospheric or magnetic storms, and no effect could be detected arising from certain changes in the transmitting aerial.

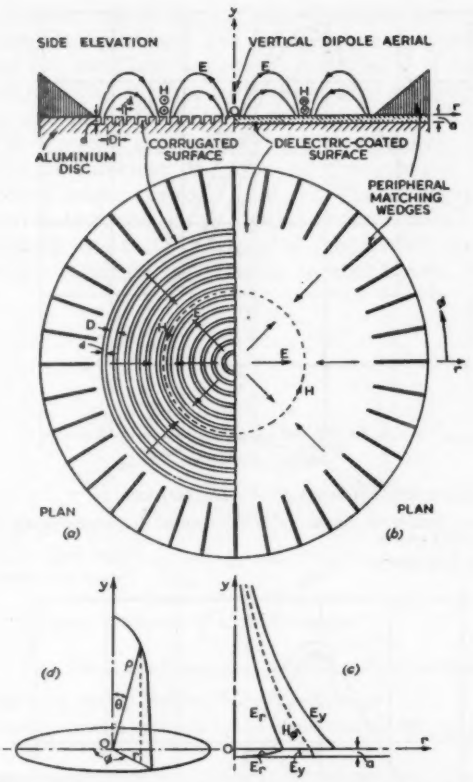
621.396.11 : 621.317.34.029.6

Cylindrical Surface Waves

A short review of a Radio and Telecommunication Section paper (No. 2009) entitled 'An Investigation of the Properties of Radial Cylindrical Surface Waves Launched over Flat Reactive Surfaces', by W. M. G. Fernando, B.Sc.(Eng.), Associate Member, and Professor H. M. Barlow, Ph.D., B.Sc.(Eng.), Member. The paper is published this month in Part B of the Proceedings.

A 'SURFACE WAVE' IS CHARACTERIZED BY ITS ABILITY TO travel along an interface between two different media without radiating, so that the only flow of energy away from the interface is that required to supply the losses in the media concerned. To comply precisely with these conditions the interface, in the direction of propagation of the wave, must be straight, but in the transverse plane it can take a variety of shapes. Thus we have for a flat surface the Zenneck wave, which has been known from theoretical considerations for many years although, until recently, it has not been identified in practical form.* Then there is the more familiar axial cylindrical surface wave supported by a single-wire transmission line—the subject of much recent work.

The recent investigation was concerned with the radial form of the Zenneck wave launched in air by a vertical aerial at a frequency of about 10 000 Mc/s, over a flat electrically loaded surface (see Fig. 1). The object was to examine the behaviour of this wave, with regard to both its field distribution and its launching efficiency from a vertical dipole at different heights above the supporting surface. A large flat sheet of aluminium, shown in Fig. 2, either coated with a thin layer of dielectric or corrugated by a series of ridges concentric with the dipole, formed

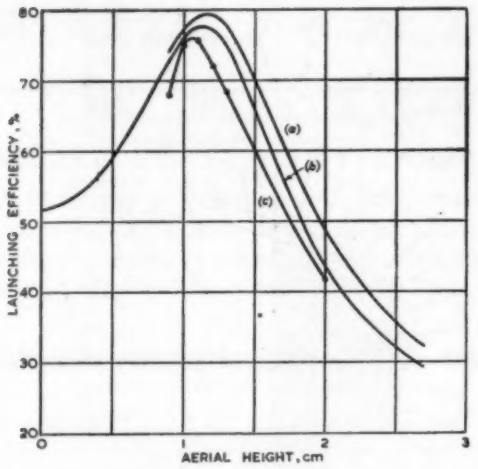


1 *Loaded aluminium disc supporting a radial cylindrical surface wave*

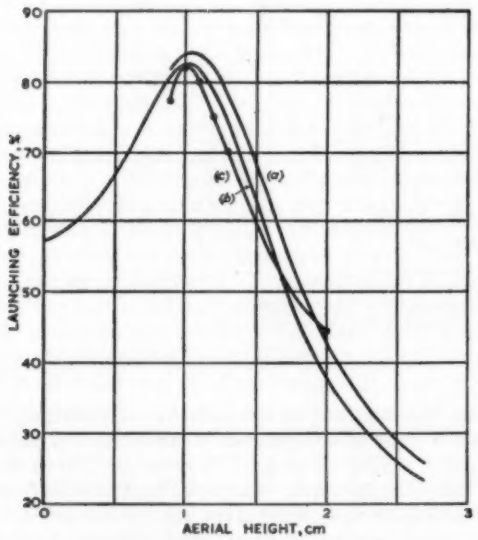
(*a*) Corrugated surface.
(*b*) Dielectric-coated surface.
(*c*) Distribution of field components.
(*d*) Cylindrical and polar co-ordinates.

2 *Experimental apparatus*

* BARLOW, H. M., and CULLEN, A. L.: 'Surface Waves', *Proceedings I.E.E.*, Paper No. 1482 R, April 1953 (100, Part III, p. 329).



3 *Launching efficiency for coated surface*
(*a*) Half-wave dipole. (*b*) Point source. (*c*) Experimental results.



4 *Launching efficiency for corrugated surface*
(*a*) Half-wave dipole. (*b*) Point source. (*c*) Experimental results.

the surface required. In accordance with the essential character of a surface wave the field does not suffer any change of phase over the wavefront, and the particular field considered here would be expected to show a simple exponential decay with height above the surface as in Fig. 1(*c*). In the radial direction along the surface a field varying as a Hankel function is predicted. A theoretical study of the problem of launching a plane surface wave from a horizontal slot as a radiator over a flat surface of this kind was made by Cullen, and he concluded that when the slot was at a particular height above the surface a launching efficiency of the order of 80% was possible. He showed that in these circumstances at large distances from the source there should be a very considerable measure of cancellation of the radiation field near the surface by interference between the direct and reflected waves, thus ensuring that most of the power went into the surface wave itself. In the present work Cullen's analysis has been extended to cover the experimental arrangement of a vertical dipole radiator of finite dimensions (instead of a narrow slot) used to propagate radially over a flat surface. The measurements made show good agreement with the theoretical predictions both in regard to the field distributions and to the launching efficiency for different heights of the aerial.

Fig. 3, for a dielectric-coated surface, and Fig. 4, for a corrugated surface of about the same loading, show that surface-wave launching efficiencies of the order of 80% are indeed obtainable when the height of the aerial above the surface is suitably adjusted. As a result of this work it may therefore be claimed that waves of this kind can be launched with high efficiency over loaded surfaces from radiating apertures of strictly limited area and that the earlier requirement of a radiator whose aperture extends to a great height does not in fact have to be met.

621.371 : 621.396.674.1

Microwave Spectrometer

A short review of a Radio and Telecommunication Section paper (No. 2008) entitled 'A Centimetre-Wave Parallel-Plate Spectrometer', by P. H. Sollom, O.S.B., B.Sc., Ph.D., and J. Brown, M.A., Ph.D., Associate Member. The paper is published this month in Part B of the Proceedings.

THE SIMILARITY OF THE BEHAVIOUR OF MICROWAVES AND that of light may be used as the basis for designing microwave instruments. The optical properties of a loss-free material can usually be described by one parameter, the refractive index, whereas the electromagnetic properties involve two quantities, usually taken as the permittivity and the permeability. The refractive index is given by the geometric mean of the relative permittivity and the relative permeability, so that if the latter is unity, as is the case for most materials at microwave frequencies, the refractive index can be used to specify the material. The electrical properties can then be calculated from an optical type of measurement which gives the refractive index.

The normal method of measuring electrical properties at microwave frequencies is to use a cavity resonator in a way which is essentially the same as the Hartshorn–Ward technique employed at radio frequencies. This is usually much simpler than an optical method because less equipment is required, and it is also inherently more accurate. Optical methods, however, are useful at the very short wavelengths (of the order of 1 mm) now

becoming available and for which it is difficult to make accurate resonators. They can also be used for the so-called artificial dielectrics, which are formed by regular arrays of conductors and cannot be fitted into resonators. Finally, optical methods can be readily adapted to investigate non-isotropic materials, the properties of which depend on the direction in which they are measured.

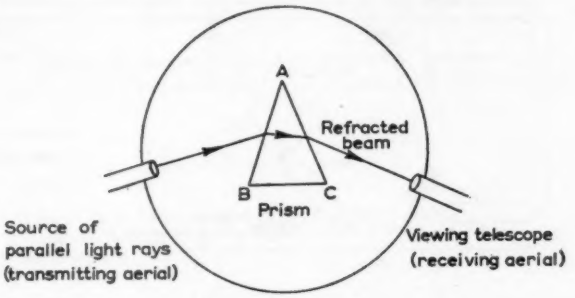
There are two basic types of optical instrument suitable for making refractive-index measurements—the interferometer and the spectrometer. Examples of each, suitable for microwave frequencies have been given by several workers, notably Culshaw. The interferometer relies basically on a direct measurement of the phase delay experienced by a plane wave in travelling through a parallel-sided slab of the material investigated. In the spectrometer, on the other hand, a sample in the shape of a triangular prism is used, and the quantity which is measured directly is the change in the direction of travel of a wave which has passed through the prism. The refractive index of the material can be calculated from this angle by using Snell's law.

The work described in the paper was carried out as part of a programme on the properties of artificial dielectrics, and an optical-type instrument was desired mainly for the investigation of the dependence of refractive index on the direction of propagation. For this purpose a spectrometer is more suitable than an interferometer. The possibility that the instrument may eventually be used for measurements on diffraction gratings and certain types of aerial was allowed for in its design by certain special features.

The spectrometer takes its name from the spectrum produced when a beam of white light is passed through a prism. The various frequency components in the incident light can be separately examined by this means, and one of the most common uses of an optical spectrometer is the examination of the frequency distribution of various light sources. Much useful information on the structure of various materials has been obtained by using a sample of the material, heated to a sufficiently high temperature, as the source. The examination of the spectra which are obtained forms the subject of spectroscopy. Since the Second World War a new branch of this subject, microwave spectroscopy, has been developed, and in this the variation of the attenuation coefficient of a material with frequency is examined. It might well be thought a microwave spectrometer would be used, but in practice microwave-spectroscopy measurements are made with a variable-frequency oscillator and receiver to give the necessary frequency resolution, which is then very much greater than could be obtained with an instrument relying on changes in refractive index.

Since a microwave spectrometer is not used for spectroscopy, there appears little justification for the name apart from the similarity in construction to the optical instrument. Essentially, the microwave instrument resolves the angular distribution of energy in a radiated wave; in other words it gives some information about the function which Booker and Clemmow have called the angular spectrum. The name microwave spectrometer can therefore be justified, provided it is remembered that what is examined is the angular spectrum of a wave and not its frequency spectrum.

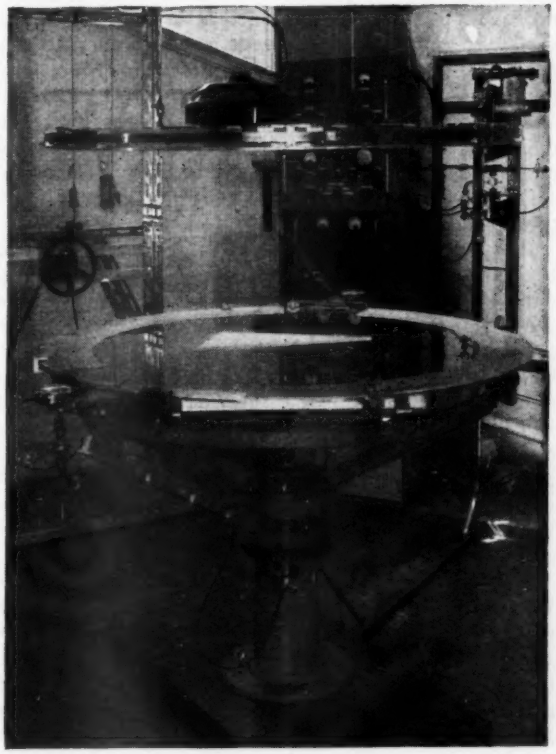
The essential components of a spectrometer are a source of radiation, a prism of the material being examined and a detector (Fig. 1). The radiating and detecting apertures in an optical instrument are large compared with the wavelength of light so that the light can be considered to travel in parallel beams, whose

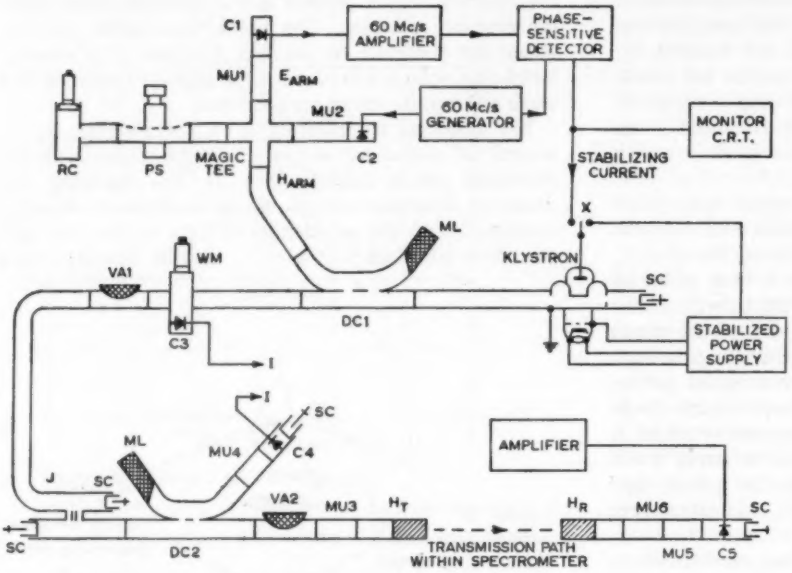


1 *Principal components of a spectrometer*

2 *General view of the completed spectrometer*

The top plate is shown in the raised position for the insertion of test specimens.





3 *The microwave circuit for the spectrometer*

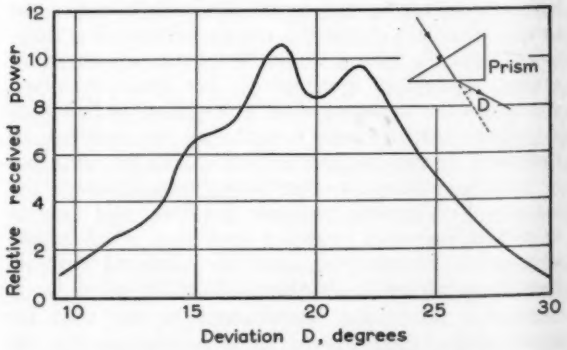
C	crystal holder.	J	rotating joint.	RC	reference cavity.
DC	directional coupler.	ML	matched load.	SC	short-circuiting plunger.
H_R	receiving horn.	MU	matching unit.	VA	variable attenuator.
H_T	transmitting horn.	PS	phase shifter.	WM	wavemeter.

behaviour can be predicted by assuming rectilinear propagation. At even the smallest radio wavelengths available, only a relatively crude approximation to this can be achieved, and it becomes necessary to consider the wave nature of the radiation, as shown by interference and diffraction effects, in interpretating the results. The difficulties are least for the shortest available wavelength, and the instrument described operates at a wavelength of 1·25 cm, which was the shortest readily available when construction was started.

Previous microwave spectrometers have used radiated beams of approximately square cross-section travelling freely in space. The prisms must then have dimensions of the order of 10 wavelengths and are quite bulky; in the present instrument the radiation is constrained to travel within two parallel plates $\frac{3}{16}$ in apart. Not only does this reduce the thickness of the prisms required to the same value, but it also minimizes the risk of interference between the signal arriving at the receiving aerial via the prism, and signals of unknown and changing amplitude arising from reflection at the walls of the laboratory and from the operator. The penalty is that only waves with electric field perpendicular to the plates can be used.

The complete spectrometer is shown in Fig. 2, in which a test prism is lying on the lower plate. The upper plate is raised by a hoist and during measurements it rests on the absorbing spacing layers which are positioned around the circumference. The aerials are both on carriages which can be rotated around the edge, the angular positions being indicated on a scale fitted to the upper plate. The diameter of this plate was made 360 cm so that the scale is formed by four 90 cm sections of steel rule. The transmitting aerial is connected to a klystron oscillator by means of a rotating joint in the central pillar. The remainder of the microwave apparatus is indicated in the block diagram (Fig. 3).

A series of measurements have been carried out to determine whether the spectrometer has been accurately constructed, and to give an estimate of the likely errors which will arise as a result of diffraction. The most important tests have been carried out using a polystyrene prism (the one shown in Fig. 2), whose refractive index has been measured under a variety of conditions. The first difficulty is that of estimating the precise direction in which the wave is emerging from the prism. In an optical system using monochromatic light, the receiver in Fig. 1 indicates a signal for only one definite angular position, but with microwaves there is a spread of radiation resulting from the dimensions of the prism and aerial apertures being comparable with the wavelength of the radiation. A typical response curve, in which the received signal power is plotted against the angular position of the receiver expressed as a deviation from the direction of the incident wave, is shown in Fig. 4. Not only is there an appreciable signal over a range of some 20°, but there is an oscillatory component which complicates the problem of selecting the direction of maximum signal. Experience has shown that when the response



4 *The variation of receiver power against deviation for a polystyrene prism*

Inset diagram shows the path of the ray through the prism and the angle measured. The hypotenuse of the prism was 45·5 cm.

curves are plotted on a reasonably large scale, it is possible to estimate by eye the effective 'centre of gravity' of the curve to within 0·25°, and that consistent results can be obtained. The direction of the incident beam is taken to be that given by the 'centre of gravity', and the validity of this procedure was checked by measurements on a reflecting barrier placed along a diameter of the spectrometer.

The ripples on the response curve have been shown to indicate the presence of a second beam at the receiver arriving from some other direction; it has been possible to use the periodicity and position of the ripple maxima to deduce the direction from which this interfering signal is coming. In the results examined the cause of the interfering signal was always quite obvious once its direction had been established, the two most common causes being side lobes radiated by the transmitter and reflections from boundaries such as the side BC of the prism in Fig. 1. Confirmation of this explanation of the ripples has been found by showing that they disappear when the receiving aerial is shielded from the interfering radiation.

An unsolved mystery associated with the instrument is that the first results with the prism gave values of refractive index some 4% too low. After an exhaustive series of tests, which appeared to eliminate all the likely sources of error, it was found that values correct to within $\pm 0{\cdot}5\%$ could be consistently achieved, provided that the prism faces which are in contact with the spectrometer plates were first coated with tin-foil. No explanation for the improvement in accuracy resulting from the use of the tin-foil has yet been forthcoming.

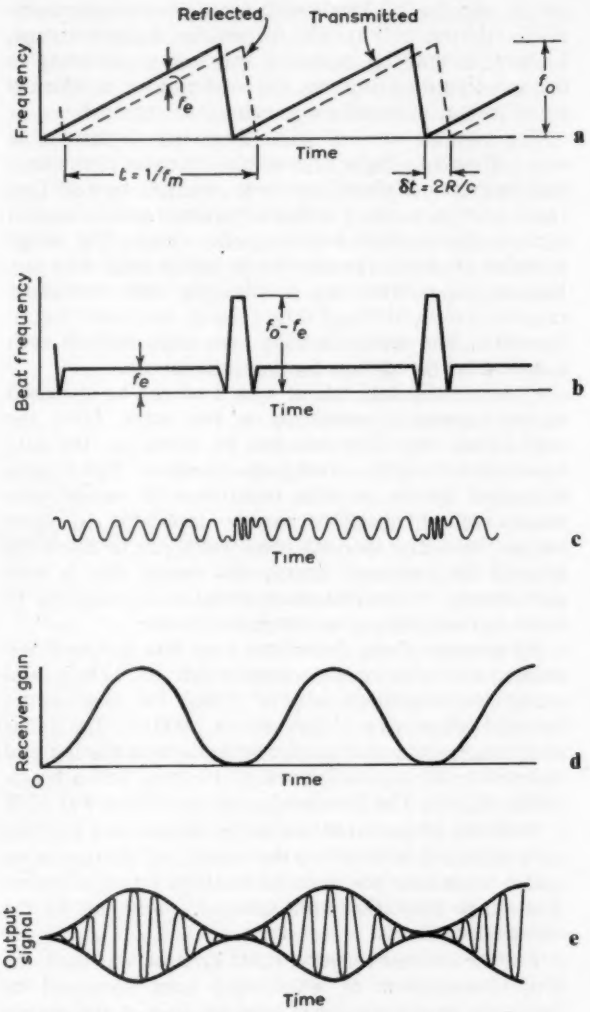
621.317.74 : 621.315.61 : 538.566

F.M. Radar for Navigation

A short review of a Radio and Telecommunication Section paper (No. 1940) entitled 'Frequency-Modulation Radar for use in the Mercantile Marine', by D. N. Keep, B.Sc.(Eng.), Associate Member. The paper was published individually in November, 1955, and it will be republished in Part B of the Proceedings.

FREQUENCY-MODULATED RADAR MAY BE DEFINED AS A continuous-wave transmission which is frequency modulated in a known manner in order to obtain range information. Normally the frequency modulation is linear and the transmitted and received signals differ in frequency by $2(R/c)df/dt$, where R is the range of the target and c the velocity of electromagnetic waves. This difference frequency may be extracted by beating the received energy with a fraction of the transmitted energy, as shown in Fig. 1.

In a practical system the modulation must be repetitive over a limited range and a sawtooth waveform with a very rapid flyback is used, the receiver being desensitized



1 *Method of obtaining echo signals in f.m. radar*

(*a*) Frequency variation of signals. (*b*) Beat frequency for one target. (*c*) Beat frequency waveform, exaggerated. (*d*) Receiver gain modulation. (*e*) Beat frequency after gain modulation.

during the flyback. The beat frequency then consists of a series of long pulses which have a Fourier spectrum usually containing two or three significant components; because of this the ideal receiver is a set of frequency filters of band-width f_m, separated by f_m, where f_m is the modulation repetition rate.

When such a receiver is used it can be shown that f.m.-radar performance is theoretically equal to that of equivalent-pulse radar using the same mean power, frequency spectrum, etc., the absolute range resolution of both being proportional to the total band-width occupied.

When compared with pulse radar, f.m. radar possesses two major advantages. There are no peak-power require-

ments, and the full band-width for a given range resolution is required only at radio frequencies. A disadvantage, however, is that the receiver is very bulky, consisting as it does of a group of filters, the total number of which is equal to the fractional range resolution required.

The possible use of wide frequency deviations is very pertinent to high-range-resolution radar equipment, and furthermore there is a more practical type of f.m. radar receiver in which a single-frequency gate is used to explore the required beat-frequency range. The range scanning produces a proportionate loss in radar data rate because the receiver can handle only one element of range at a time, although target signals are received continuously. The aerial scanning rates obtainable in such a system are far too low for navigational use.

However, the data rate of such a set can be increased at the expense of sensitivity in two ways. First, the modulation repetition rate can be increased, the gate band-width being increased proportionately. This process is limited by the possible occurrence of second-trace echoes and is therefore mainly applicable to short ranges. Secondly, the gate band-width can be increased beyond the optimum figure; this means that a proportionately wider frequency deviation is required in order to maintain a given range resolution.

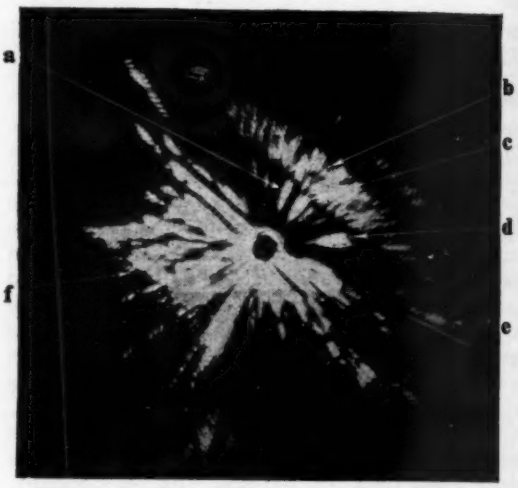
By progress along these lines a set was designed and constructed with a gate band-width of 12 kc/s and modulation repetition rates of 10 kc/s for range scales below 1 000 yd and 2½ kc/s above 1 000 yd. The radar aerials were twin cheeses (for separate transmission and reception) with a rotation rate of 10 r.p.m. and a beam-width of 1·7°. The fractional range resolution was 1/30.

With the longer-range scales the transmitting klystron gave an output of 80 mW to the aerials, and the maximum useful range scale was found to be about 9 nautical miles. The range resolution and sensitivity were up to the expected standards.

For the shortest ranges a K302 klystron was used, the f.m. characteristic of which had been linearized by feeding it into a frequency-sensitive load of the correct magnitude. Under these conditions a linear frequency sweep of 36 Mc/s was obtained. A short-range picture (100 yd maximum range) is shown in Fig. 2. The radar equipment was situated close to a beach at Southsea, Hampshire, but this range scale was entirely over land. The fractional resolution on this range dropped to about 1/10 mainly because the klystron frequency sweep was not sufficiently linear to obtain the full 1/30 range resolution of the set at these ranges. Nevertheless, it was used for demonstration purposes because it brought into view a number of discrete targets that were easily recognized, including people on the promenade. An important point about the short-range performance is the very high brilliance obtained on the display, since the cathode-ray-tube beam sweeps continuously at a fairly low speed.

It can be concluded that f.m. technique can be best utilized for short-range high-resolution radar sets, but before these become a practical possibility, transmitting valves capable of being swept over wide-frequency ranges at high speeds must become available. Fortunately there are one or two promising new developments in this direction.

A more fundamental problem is that of further increasing the data rate of an f.m. radar system without the complexity of a multi-gate receiver. One solution would be to use several sweeping gates, each one of which would handle part of the range scale. The outputs would have to be combined in order to give a conventional p.p.i. picture, but this should not present any serious technical problems. 621.396.969



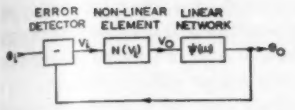
2 *P.P.I. photograph—100 yd range scale, 15 mW transmitted*
(*a*) Lamp-post. (*b*) Shingle beach. (*c*) Seat. (*d*) Man walking along promenade. (*e*) Lamp-post, 70 yd range. (*f*) Buildings.

Non-Linear Feedback Analysis

A short review of a Measurement and Control Section paper (No. 1877) entitled 'The Dual-Input Describing Function and its use in the Analysis of Non-Linear Feed-Back Systems', by J. C. West, Ph.D., Associate Member, J. L. Douce, M.Sc., Ph.D., Graduate, and R. K. Livesley, Ph.D. The paper was published individually in July, 1955, and it will be republished in Part B of the Proceedings.

THE PAPER PRESENTS A GENERAL TECHNIQUE FOR THE analysis of a class of feedback systems incorporating one non-linear element. The response to a sinusoidal input is derived by considering the system in two parts as shown in Fig. 1, a linear portion whose gain is frequency-dependent, and a non-linear portion whose gain is a function of amplitude only.

Previous work has assumed that the input to the non-linear element is sinusoidal, and this assumption gives valuable information concerning the stability and



1 *Basic system*

frequency response of the complete system. The paper considers the input v_i to be of the form

$$v_i = a \cos \omega t + b \cos (n\omega t + \phi)$$

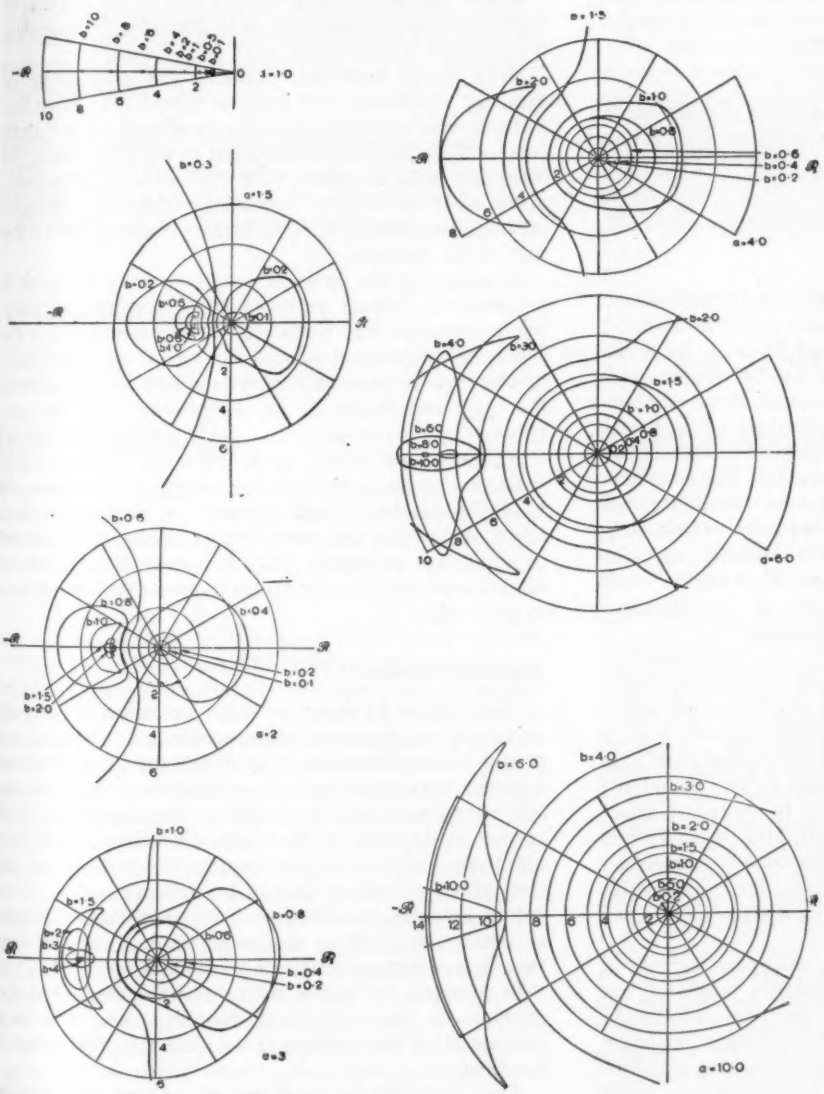
The gain of the non-linear element for either frequency component is defined as the amplitude of the output at the frequency considered divided by the amplitude of the input of this frequency. By means of this approach, many phenomena observed in non-linear systems may be explained quantitatively.

The first phenomenon analysed is the 'jump' effect. This effect is observed when steady-state analysis of the sinusoidal response predicts three possible values for the output amplitude. In practice, only two output amplitudes are observed, so that the third solution must be regarded as unstable. By considering the response of the system to a small signal in the presence of the primary input, it is shown that, under certain conditions, the response to a slight disturbance increases indefinitely with time. This implies that the initial conditions are, in fact, unstable.

A further effect investigated is the production of sub-harmonics, observed when the non-linear system oscillates at a frequency which is an exact submultiple of the input frequency. This phenomenon can occur in systems which are non-oscillatory for zero input and which have a well-damped response to a step input. Criteria are developed for the absence of these oscillations in any system in which the non-linear elements considered are present.

The behaviour of a system which is conditionally stable in the Nyquist sense has also been investigated. It is found experimentally that self-maintained oscillations can be initiated in such a system by the application of a sinusoidal signal of sufficient amplitude. It is of practical importance to determine the input amplitude of any frequency such that these oscillations build up. The technique of the dual-input describing function gives a physical explanation of this phenomenon as well as quantitative data concerning the critical input amplitude at any particular frequency.

A further application of the technique is the accurate evaluation of the harmonic content in the response of a system to a sinusoidal oscillation. By considering this harmonic component as a forced oscillation of the system, the steady-state conditions are evaluated by means of an extension of the describing function technique. The theory developed shows the great importance attaching to



2 *High-frequency describing-function loci*

the open-loop frequency-response locus of the linear portion of the system.

The dual-input describing function is evaluated for two types of non-linearity. First, the cubic type is considered, an algebraic analysis being used to derive the required gain. This is not possible for the second type, which is that of symmetrical saturation, and the Manchester University digital computer has been employed to give general results for this case, some of which are shown in Fig. 2. An outline is given of the method by which this calculation is performed by the machine. Experimental work has verified the theoretical analysis for particular systems. 621–52

Solving Power Problems

A short review of a Graduate and Student Section paper entitled 'Modern Techniques in Solving Power Engineering Problems', by J. H. Banks, M.Sc., Graduate. The paper was awarded a Students' Premium by the Council, and a long abstract of it was published in March, 1956, in the Students' Quarterly Journal.

OWING TO THE UNPRECEDENTED GROWTH OF ELECTRICAL power systems, many of the earlier forms of analysis are only approximate when applied to large networks unless an unmanageable amount of hand computation is undertaken. Development has consequently taken place in both the analogue and analytical methods of investigation. In the analogue field earlier electrical models of the d.c. pattern have been succeeded by a.c. type analogue devices which possess much greater flexibility. In the analytical field, methods have been devised whereby the routine numerical computation incurred may be performed in a standard manner. This allows such computation to be performed either by non-technical staff or by automatic computing machines.

The conventional type of a.c. network analyser represents power-system components directly in miniature, in contrast to the Blackburn type where all impedance units are of a universal pattern derived from a transformer analogue. Whilst direct representation aids clarity, greater flexibility is possessed by the Blackburn type of machine through its ability to represent impedance co-ordinates in any quadrant, and its additional mathematical properties. Mutual-impedance representation is possible without complication, permitting facile setting-up of groups of linear simultaneous equations for direct solution.

Conventional-type a.c. network analysers have been designed capable of dealing with transient problems, but it is necessary that all units of the analyser remain constant in value, at a particular setting, over a frequency range of 0–15 kc/s. Since power-system transient problems are seldom encountered where the frequency range exceeds 100/1, the analyser may be modelled in frequency to meet such a range by choosing a base frequency of 1·5 kc/s. The analyser components will thus be responsive to frequencies ten times below and ten times above this base frequency, viz. over the range 150 c/s–15 kc/s.

The general design follows that of the conventional steady-state analyser, except that the equipment may consist of a much smaller number of units, since appreciable influence is exerted only by those components of the system which are near the transient disturbance. A function generator is required to produce the various types of forcing function simulating the transient disturbance.

Use of Digital Machines

Where mathematical problems are to be solved by digital computing machines, it is desirable to formulate the problem in a standard way.

Since these machines perform the operations of ordinary arithmetic, they may be regarded as providing a direct mechanization of the role played by a human computer. A problem is presented to the machine in the form of a series of orders, each calling for an elementary arithmetical or transfer operation, which the machine executes sequentially without further intervention on the part of the operator.

In preparing the series of orders or programme, it is necessary to foresee every possible contingency, since the machine can add nothing to what is contained in the orders punched on the cards. It is only the computing function of the human computer which is mechanized; the logic and design of the programme must be contributed by the operator.

Although the initial preparation of a programme requires extensive arithmetical analysis, it is permanently available for future use whenever a similar problem arises. Automatic computers are therefore ideally suited to repetitive processes, and they may be applied to several mathematical operations in power system analysis to great effect.

Analytical Methods

The classical treatment of faults by means of network reduction and symmetrical components is often a long process if the network is large. When the interconnected sequence networks have been reduced to a single equivalent impedance, and the sequence components of fault current at the point of fault have been determined, it is often required to find the distribution of fault current throughout the greater part of the network.

For complex networks, and, in particular, networks in which simultaneous dissymmetries are encountered, the solution becomes extremely cumbersome.

In contrast, the use of matrix techniques enables the problem to be formulated concisely, and the final evaluation of the matrices is an ideal task for a digital machine.

The equations of performance of any multi-mesh network may be written down by applying Kirchoff's

laws or more directly by the use of Stigant's rule. These equations are of the form:

$$V_1 = Z_{11}I_1 + Z_{12}I_2 + Z_{13}I_3$$
$$V_2 = Z_{21}I_1 + Z_{22}I_2 + Z_{23}I_3$$
$$V_3 = Z_{31}I_1 + Z_{32}I_2 + Z_{33}I_3$$

or, an alternative matrix definition:

$$\begin{vmatrix} V_1 \\ V_2 \\ V_3 \end{vmatrix} = \begin{vmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ Z_{31} & Z_{32} & Z_{33} \end{vmatrix} \cdot \begin{vmatrix} I_1 \\ I_2 \\ I_3 \end{vmatrix}$$

In this V represents the driving voltage in each mesh, I represents the current and Z the impedance. The unknown mesh currents may then be evaluated by the solution of this matrix equation.

Matrix Treatment of a Single Line-to-Neutral Fault

The positive, negative and zero-sequence networks are first delineated independently from consideration of the power-system circuit diagram. They are then interconnected at the point of fault to meet the constraints imposed by the fault, without preliminary reduction of each sequence network.

For the shunt fault considered, the relationship

$$I_1 = I_2 = I_0$$

exists between the sequence components of fault current, and the three sequence networks are connected in series. Mesh currents are defined in each closed mesh, the equations of performance of the interconnected network are written down directly with the aid of Stigant's rule, and the equations may be evaluated swiftly by automatic digital computer.

The phase currents at the point of fault or at any other location in the network are obtained by combining the respective sequence components of current.

The method is concise and rapid, in contrast to earlier methods involving extensive network manipulation and the calculation of fault-current distribution.

The method may be applied without further complication to all types of unsymmetrical faults including simultaneous dissymmetries. The presence of phase shifts due to lack of balance introduces no further difficulties in principle. 621.315.09 : 518.5

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* without being read at an Institution meeting which have not been described elsewhere in the *Journal*.

Lossy Waveguides

A synopsis of a Radio and Telecommunication Section paper (No. 1969) entitled 'A New Treatment of Lossy Periodic Waveguides', by P. N. Butcher, Ph.D. The paper is published this month in Part B of the Proceedings.

THE CONVENTIONAL TREATMENT OF PROPAGATION coefficients in lossy periodic waveguides suffers from certain major defects. It gives no information about the effects of the losses on the phase-change coefficient, it breaks down when the frequency approaches the edge of a pass-band from within and it does not work at all in a stop-band. A new treatment is described which removes all these defects. It is based on the following result: the propagation coefficient of a mode in a lossy guide at the frequency ω is equal to the propagation coefficient of the corresponding mode in the lossless guide at the frequency $\omega(1 - j/2Q_c)$. Here, Q_c is the *complex quality factor* of the mode at the frequency ω. It is given by an explicit formula which holds good at all frequencies when the losses are small. When ω lies within a pass-band, Q_c is equal to ω times the mean energy stored in a period of the guide divided by the complex power dissipated in a period of the guide. When ω lies in a stop-band, Q_c is equal to the analytic continuation of its values in the pass-bands. 621.372.8.017

Q-Factor Measurement

A synopsis of a Radio and Telecommunication Section paper (No. 2037) entitled 'An X-Band Magnetron Q-Measuring Apparatus', by J. R. G. Twistleton, B.Sc., Associate Member. The paper is published this month in Part B of the Proceedings.

THE Q-FACTORS OF A RESONANT-CAVITY MAGNETRON ARE usually estimated (in terms of the frequency band-width of a resonance curve) from measurement of the standing wave which exists in a feeder through which power is supplied to the magnetron at, and near to, its resonant frequency. The accuracy of this method is high, but when changes in Q-factor are to be measured, which, for example, may result from changes in the output coupling or tuning of the magnetron, its application is tedious.

The use of a directional coupler replacing the standing-wave indicator to monitor the reflected power is well known. Such a coupler may be used in conjunction with a frequency-swept oscillator and cathode-ray tube to give a visual display of the magnetron resonance curve. An apparatus of this type which was used for the qualitative examination of magnetron resonances in the 3 cm waveband is described, and details of an improved equipment which may be used to measure magnetron Q-factors are given, together with a discussion of the accuracy of measurement which may be achieved.

621.317.74 : 621.372.8 : 621.385.16.029.6

HOME EVENTS

LONDON

MEASUREMENT AND CONTROL SECTION

A Powerful Method—for use with Servos and Discretion

The paper on *The Dual-Input Describing Function and its use in the Analysis of Non-Linear Feedback Systems* presented to the meeting on the 13th March by Dr. J. C. West, Dr. J. L. Douce and Dr. R. K. Livesley gave an interesting method of analysis using the 'dual-input describing function'. A short review of the paper appears on p. 288.

The talk about the principles involved, with hardly a reference to the paper, was given in an easy, confident and pleasing manner by Dr. Douce, whom the Chairman, Mr. W. Bamford, afterwards referred to as 'another promising colt from the Dr. West stables'. Some illustrations additional to those in the paper were used and the subject was described in such a manner that, even if the mathematics was not immediately comprehensible to the average listener, the ideas underlying the method of analysis were well conveyed to him.

As the paper was one for the specialist, the audience attracted was very small, numbering 24 in all, and the spirit of the meeting was intimate and friendly.

In the discussion which followed the presentation of the paper it was emphasized that, although the method itself is powerful, it must obviously be used with discretion and that such discretion should be based on practical experience with servos and in particular with the stability of servos. Assumptions must be made and approximations appear in the result from these assumptions. The result must thus be checked by practical tests and the validity of the assumptions verified.

Mr. P. E. W. Grensted made an able contribution stressing these general points; he also picked up minor discrepancies or contradictions of description appearing in the paper, and questioned whether the describing function is the gain of the system or its reciprocal. He said that apparently the Russians have used a mathematical method analogous to the method described by the authors and anticipated by some two or three years the authors' main reference.* Mr. E. A. Freeman made some criticism of Mr. Grensted's contribution.

A portion of the discussion was devoted to the 'jump' phenomenon which was illustrated by Dr. Douce by a slide shown during his lecture. The illustration itself does not appear in the paper. The 'jump' referred to is a discontinuity in the amplitude of the output exhibited by a non-linear system as the frequency is increased and saturation occurs; the curve shows, as the frequency is decreased, an apparent hysteresis loop. Mr. Freeman referred to the possibility also of a phase change occurring with the 'jump'.

The physical conception of these functions is somewhat difficult to visualize, and Mr. J. Bell tried to illustrate them from experience gained with the operation of a system beyond saturation applied to the stabilization of equipment on board ship. On the blackboard he drew an input wave of constant frequency and of increasing amplitude; a servo follow-up curve having a limiting speed (saturation) was also drawn, and the point of discontinuity was readily apparent where the amplitude of the following curve reaches approximately constant amplitude. The resulting phase change also was apparent, but not the hysteresis effect claimed by the authors.

Dr. West was obviously glad of the opportunity now afforded him to reply to the discussion and entered into his task with zest, enlarging upon the use of the Nyquist diagram and extending it to cover the condition of an open loop with an incremental perturbation of input. He did agree, however, that the mathematics involved must be well backed by experience and intuition to obtain a real solution.

The meeting closed with a few words from the Chairman thanking the authors and the discussion speakers for their contributions to the meeting. J. B.

* KOCHENBURGER, R. J.: 'A Frequency Response Method for Analysing and Synthesising Contactor Servo-mechanisms', *Transactions of the American I.E.E.*, 1950, **69**, Part I, p. 270.

MEASUREMENT AND CONTROL AND SUPPLY SECTIONS

Needle Work

A well-attended joint meeting of the Measurement and Control and the Supply Sections, under the chairmanship of Mr. W. Bamford, listened with interest on the 28th February, 1956, to the reading of a paper entitled *An Evaluation of Two Rapid Methods of Assessing the Thermal Resistivity of Soil* by M. W. Makowski and K. Mochlinski.

The authors briefly dealt with the factors controlling soil thermal resistivity g, and with older methods of its measurement, which had the general demerits of slowness and soil disturbance. They then outlined the theory of the transient-needle method, its practical application, and the probable errors arising from apparatus designed for field use. An alternative method, based on soil sampling with a specially designed tool and subsequent laboratory determination of composition, dry density and moisture content, was then considered, both in theory and in practice. The results of a number of comparative tests were examined, and it was concluded that the two rapid methods were capable of giving results adequately accurate for most practical purposes.

The discussion underlined the economic importance of knowing g, affecting as it does, to a marked extent, the permissible rating of buried cables. The interrelation of g and soil moisture was emphasized, and it was suggested that, as the needle-probe method could not measure soil moisture, a combination of the two methods might yield the most useful data. It was also emphasized that seasonal variation of soil moisture was a most important factor, and that more knowledge about moisture migration near a loaded cable was necessary.

There was criticism that the needle probe did not truly simulate a buried cable, nor could it be used in very stony soil. This criticism was answered along the lines that, if necessary, the needle probe could be buried in the back filling adjacent to the cable, and used to measure g at any subsequent time, and that such back filling was seldom stony adjacent to the cable, which was where g mattered.

Some suggestions were put forward to improve the practical application of the needle-probe method; some speakers thought that more comparative testing was necessary to justify the authors' conclusions, but it was pointed out that from the very nature of the subject the verification of the worth of the methods would be best achieved if the many engineers interested in the subject would undertake extensive testing and make their results available for collective study.

One speaker evidently conscious of the 'earthy' nature of the subject, and anxious that the discussion should remain equally earth-bound, exhorted those concerned with cables 'not to lose sleep over a few amperes'!

The frequent reference in the discussion to needles and probes evidently stirred memories in the mind of Mr. Drucquer, Chairman of the Supply Section, who, in thanking the authors, said he regarded the Measurement Section as the wielder of the needle, and the Supply Section as the patient. Both parties were obviously interested, but the patient's interest was probably the more intense. However, the treatment was beneficial if it resulted in the better use of increasingly costly and scarce materials. H. S. P.

RADIO AND TELECOMMUNICATION SECTION

At the meeting of the Radio and Telecommunication Section on the 7th March Mr. D. N. Keep read a paper on *Frequency-Modulation Radar for use in the Mercantile Marine*. As the Chairman, Mr. H. Stanesby, remarked, it was a long time since the Section had devoted an evening to radar, and it was the first time that this particular type of system had been discussed.

The author began by outlining the principles of an f.m. radar system and the main points in the design of a set. He continued by comparing the merits of pulse-modulated and f.m. systems—an aspect of the subject which received much attention in the subsequent discussion. A continuously-scanning single-gate f.m. system had been built by the Royal Naval Scientific Service on behalf of the Ministry of Transport and Civil Aviation for the purpose of examining its possibilities for applications in the mercantile marine. After describing its salient features, the author showed photographs of the p.p.i. display on 9-mile and 100 yd range scales, and succeeded in pointing out the significance of the echoes in spite of the unfamiliar appearance of the picture due to incorrect orientation of the slide. The two main problems facing further development were those of obtaining transmitting valves capable of wide frequency sweeps and of increasing the fractional range resolution without decreasing the aerial scanning rate. A short review of the paper appears on p. 287.

The discussion covered a wide range of topics, and, contrary to the usual practice, the author replied to each speaker at the conclusion of his remarks.

Mr. N. M. Rust, who opened the discussion, said that he was disappointed with the definition of the short-range p.p.i. picture; he thought that it did not do justice to the f.m. system. He suggested possible reasons for the lack of resolution and described his own experiences with that type of radar equipment. Other speakers also commented on the resolution.

Several speakers compared pulse-modulated and f.m. systems. Mr. A. P. L. Milwright spoke of the greater complexity of the f.m. set and its inferior range discrimination at longer ranges, while Mr. J. Croney emphasized the higher brilliance of the picture at short ranges compared with that obtained on pulse-radar sets. Mr. G. R. Nicoll claimed that pulse radar could do all that f.m. radar could do. The general opinion, however, seemed to be that while the pulse system was more suitable for most navigational purposes the f.m. system had a promising field of application for docking and harbour surveillance.

Dr. R. L. Smith-Rose recalled the early use of f.m. transmissions by Appleton and Barnet in their investigations of the ionosphere, but added that they soon adopted the pulse technique in general use to-day.

Mr. P. S. Brandon raised, amongst other points, the question of scanning the aerial over a restricted sector, and the technical advantages and navigational disadvantages of this were discussed. Dr. E. Eastwood drew attention to the use of a simplified system without a frequency sweep for the purpose of detecting moving targets by observation of the Doppler frequency shift.

In moving a vote of thanks to the author, the Chairman remarked on the most interesting evening which the paper had initiated. B. G. P.

SUPPLY SECTION

Power over Messina

On the 24th February an extra Section Meeting was held, at which Mr. F. Bianchi di Castelbianco* gave a most interesting lecture on *The Crossing of the Messina Strait*

* Mr. Bianchi di Castelbianco is with the Società Anònima Elettrificazione, Milan.

by a 230 kV Double-Circuit Overhead Transmission Line. Although details have appeared elsewhere, the following approximate particulars may be of interest:

Main crossing span	3 653 m (2·27 miles).
Overall distance between anchor structures	5 051 m (3·14 miles).
Clearance to water	70 m (230 ft).
Sag in crossing span	206 m (676 ft).
Overall height of each supporting tower*	224 m (735 ft).
Weight of each tower	440 tons.
Conductors in the cable:	
114 steel wires	each 1·8 mm diameter.
6 steel wires	each 2·1 mm diameter.
19 aluminium wires	each 1·73 mm diameter.
Overall diameter of cable	27·8 mm (1·1 inch).
Weight per unit length	1·87 lb/ft.
Tensile strength	124 000 lb.

* One tower is based about 550 ft above sea level, whilst the other is only 30 ft above the water.

Mr. Bianchi pointed out, with what seemed a slight note of envy, that the crossing of the Messina Strait is not, in fact, the longest span in the world, being surpassed by the 4 855 m (3-mile) crossing over the Sogne Fjord in Norway. The latter, however, is situated between high mountain cliffs, and tall towers are not therefore required, only low anchorages. The towers for the Messina Strait are roughly twice the height of St. Paul's Cathedral and are easily the tallest power-line towers in the world.

The history of the crossing project, from its early pre-war conception, was outlined, and some indication was given of the various changes in overall design that were considered before the final plans were settled. One gathered the impression that in the early stages the broth might have been improved by fewer cooks.

An important feature is that the Messina district is an earthquake region. Past seismic disturbances have cracked and distorted the geological strata, and the possibility of future earthquakes has led to deep single-block concrete foundations for the towers, so that stability would be maintained even if the resistant earth pressure was assumed to vanish under a large part of the foundation. In addition, the towers themselves were designed to withstand 'earthquake' loadings and stresses which would be set up by severe horizontal accelerations at the base. In the design stage, a 1/25 scale model of the tower was made and tested to simulate such conditions.

Mr. Bianchi showed a film and a large number of excellent slides illustrating various stages of erection of the towers and conductors. Erection of the main tower bodies, although clearly a major structural operation, was relatively straightforward. On the other hand, the erection of the cross-arms involved difficult problems of tackle and organization. Each cross-arm projects over 100 ft from the tower body and is more than comparable in dimensions and weight with a complete 132 kV double-circuit tower. The cross-arms were raised from the ground as completely assembled structures, and the operation of lifting them nearly 700 ft, in far from still air, without damaging them or the tower body, and finally bolting them into position, was conducive to premature grey hairs on the heads of those responsible.

Probably the most difficult problem of all, however, was that of erecting the conductors. It was unthinkable to allow them to lie on the sea bed at any stage, because of the likelihood of damage from sharp rocks and wreckage, especially in view of the great velocity and continual variation of tidal currents in the strait. Furthermore, it was desirable to keep the conductors out of the water altogether because of the possibility of subsequent accelerated corrosion due to salt deposits among the strands. It was therefore decided to pull the conductors across by pilot cables, under a tension sufficient to keep them out of the water. The pilot cables themselves, of course, had to lie temporarily on the sea bed. Considerable trouble was experienced with breakage or loss of the pilot cables due to under-sea wreckage and to the unauthorized passage of ships in spite of a carefully arranged programme of traffic stoppage through the strait. However, the conductors were eventually successfully erected, although the grey hairs referred to earlier are thought to have multiplied!

There was no time for an organized discussion, but Mr. Bianchi kindly stayed to answer numerous questions after this very successful meeting. P. J. R.

CARDIFF AND BRISTOL

WESTERN CENTRE

Mr. Metcalf finds Touch on a Home Ground

The words 'Cardiff' and 'Coal' have been so closely linked for so many years that a stranger frequently expects to find coal mines within half a mile of the famous Civic Centre. In reality, he discovers a clean, progressive city, the acknowledged capital of Wales, with fine open spaces, and the nearest coal mine seven miles away in the direction of the Rhondda Valley. However, in spite of the virtual cessation of coal exports from the docks, Cardiff continues to be highly coal-conscious and the folk from the mining valleys to the north of the city flock in for a Rugby football match or a favourite oratorio. On the 1st December, 1955, the great Sophia Gardens pavilion was crowded, not for a performance of the *Messiah*, but to hear Mr. B. L. Metcalf, well known and well liked in South Wales, give the Faraday Lecture. Mr. T. G. Dash, Chairman of the Centre and himself a mining electrical engineer, explained the purpose of the lecture and introduced Mr. Metcalf. The subject, *Coal Mining Electrically*, could not have been more suited to the audience, and the 'banksman' and 'setter on' in the demonstrations received the applause usually reserved for a Welsh tenor or an outside three-quarter. When the lecture ended the enthusiasm was genuine and wholehearted, and of the two thousand present only a handful knew that this was, in fact, a first night. Where better than Cardiff could this Faraday Lecture have been baptized? The vote of thanks was ably proposed by Major C. G. Traherne, Lord-Lieutenant of Glamorgan, and the great audience dispersed, well satisfied with the

part which electricity is playing and will play in the exploitation of the greatest natural asset of South Wales.

Replacement for Coal?

Just over a week later, and also to Cardiff, came Dr. T. E. Allibone's paper on *Nuclear Power in its Application to Electrical Generation*. The Western Centre Committee, realizing that this paper would attract a large audience, booked the Reardon Smith Lecture Theatre, an excellent modern building attached to the National Museum of Wales. Sir Hamish Maclaren, Vice-President, addressed the meeting, and after the paper numerous questions which showed the interest of the audience were dealt with by Dr. Allibone. Mr. E. K. Wood ably proposed the vote of thanks, which was carried with enthusiasm.

Charging for and Maintaining Supply

The Western Centre meetings in January and February this year were held in Bristol and Cardiff respectively, the papers presented being *Standardization of Retail Electricity Tariffs* by A. O. Johnson and N. F. Marsh, and *Automatic Circuit Reclosers* by G. F. Peirson, N. Care, and A. H. Pollard. Both meetings were well attended and excellent discussions took place. The film illustrating Mr. Peirson's paper was greatly appreciated.

B. C. R.

WESTERN UTILIZATION GROUP

Recent meetings of the Group have been well attended and the papers have catered for a wide diversity of interests. On the 28th November, 1955, Mr. C. J. Beavis, himself a member of the Western Centre, presented his paper *The Use of Electricity in the Production of Calcium Carbide*. The slides gave the audience a good grasp of the process, and the discussion which followed brought out many interesting points.

On the 23rd January, 1956, Professor F. C. Williams and Mr. E. R. Laithwaite presented their paper *A Brushless Variable-Speed Induction Motor*. Professor Williams illustrated his lecture with lantern slides and a small demonstration model. These created considerable interest, and his outline of recent development work which had been done since the publication of the paper was greatly appreciated. The discussion was opened by Professor Rawcliffe, an expert in this field, and Mr. R. F. Russell proposed the vote of thanks.

The Western Centre and its specialized Groups may be termed a 'double-headed organization' in the sense that Cardiff and Bristol claim the majority of the meetings—first one side of the Severn and then the other. Thus a paper may be read in each city during one session and this happened to Mr. J. A. Broughall's paper *The Electrification of the Manchester–Sheffield–Wath Lines*. After its success in Bristol in November, the paper had an equally good reception at a Utilization Group meeting in Cardiff on the 27th February, and an excellent discussion, opened by Mr. L. F. A. Driscoll, ensued.

B. C. R.

STAFFORDSHIRE

NORTH STAFFORDSHIRE SUB-CENTRE

New Gear for Cinderella

The fourth Ordinary Meeting was held at Stoke on the 16th December, 1955, when the paper *Automatic Circuit Reclosers*, by G. F. Peirson, A. H. Pollard and N. Care, was presented by Mr. Peirson. This paper, which was profusely illustrated by slides and a colour film, aroused considerable interest because a number of the reclosers had been installed locally and had given excellent service, especially under exceptional storm conditions in 1953, when heavy salt deposits on line insulators caused widespread interruptions of supply. Under these conditions two sets of reclosers operated 209 times in 24 hours and prevented sustained interruption of the lines protected. A recloser with tank removed was available for inspection at the meeting.

Mr. W. E. Darby opened a very active discussion which was joined by a large number of members and in which accounts of personal experiences added greatly to the interest. Mr. Peirson and Mr. Pollard replied, Mr. Care having been unable to attend. In proposing a vote of thanks Mr. A. T. Chadwick thanked the authors for their extremely detailed study of rural electrification, 'the Cinderella of the supply industry'.

The Chairman, Dr. E. R. Patrick, called attention to the shortage of papers dealing with supply and distribution subjects and said that the discussion had shown the interest which such papers could arouse. He invited members to consider presenting local papers on these subjects, which need not necessarily be given elsewhere.

Electrifying the Pennine Railways

At the meeting at Stafford on the 16th January, 1956, the Chairman formally welcomed Mr. J. Poole and Mr. C. Williams as Corporate Members. He then introduced Mr. S. E. Goodall, VICE-PRESIDENT, who expressed his pleasure in having an opportunity to meet the members of the North Staffordshire Sub-Centre, and favourably commented on the very good attendance. He described the various ways in which the Council was endeavouring to maintain the high standard of Corporate Membership, whilst at the same time actively joining in the drive to train more engineers to meet the country's need.

The Chairman then invited Mr. J. A. Broughall to read a paper on *The Electrification of the Manchester–Sheffield–Wath Lines, Eastern and London Midland Regions, British Railways*, written by himself and Mr. K. J. Cook, who was unfortunately prevented by illness from attending. The author explained that as this electrification was commenced before the war, the basic design corresponds more closely to that of 1936 than to that of to-day. It is, however, the first main line to be electrified in this country on which freight traffic predominates. Interest also centred on the long steep gradients on both sides of the Pennines, the almost con-

The Annual Dinner of the North Staffordshire Sub-Centre Photograph by courtesy of Staffs Photo Service

Standing (left to right): Messrs. W. G. Lloyd, D. K. Arkwright, J. M. Ferguson, L. D. Anscombe, W. K. Brasher and A. M. Gamble, Sir George Wade, Dr. E. R. Patrick, Sir George Nelson and Messrs. J. G. Wood, M. S. Davidson, A. R. Blandford, J. H. Pirie and E. Bolton.

tinuously curved track and the difficulties arising from the effects of mining subsidence.

The discussion, opened by Mr. J. E. Boul, ranged over all aspects of this topical subject, which offered something of interest to all engineers. Mr. R. W. Palmer moved the vote of thanks and congratulated Mr. Broughall on his genial presentation of the paper and his skill in dealing with the discussion. He was sure all had been impressed by the difficulties which had had to be overcome, not least of which would appear to be the 'pile-up' which must arise through continually running 80 trains in one direction but only 60 in the other.

A Successful District Meeting

After the success of the inaugural District Meeting at Burton last year, it was decided to arrange another for this session, and this was held on the 8th February, 1956. The convener, Mr. F. Overstall, welcomed the visitors and then introduced Mr. D. B. Irving, who read his paper on *The Supply of Electricity in the London Area*. At the close of the paper a short film illustrating the spiking of a 22 kV cable was shown, and an informal discussion followed. Mr. Overstall proposed a vote of thanks to the author. Dr. E. R. Patrick, Chairman of the Sub-Centre, expressed his pleasure at being present and thanked Mr. Overstall for the work he had done in organizing the meeting. The attendance of 55 members and guests clearly indicates that District Meetings at Burton are appreciated by the local members.

Colour Television

The meeting on the 10th February was held at the Post Office Central Training School, Stone, when Mr. L. C. Jesty gave a lecture on *Colour Television* before an audience of more than 120 members and visitors. Mr. Jesty gave a comprehensive picture of the present state of development of colour television, including a demonstration of the production of a coloured picture from component signals and assisted by excellent visual aids and colour films. He kindly agreed to a discussion on the lecture and this was opened by Mr. H. F. Lloyd. Mr. P. D. Gilbey proposed a vote of thanks to the lecturer for his very interesting exposition, which had done so much to clarify the technical problems involved. The Chairman, Dr. E. R. Patrick, thanked Mr. R. W. Palmer and members of the Training School staff for their assistance in setting up the demonstration equipment.

Knight of Gladness

The Annual Dinner was held at the Crown Hotel, Stone, on the 17th February, when the Chairman, Dr. E. R. Patrick, presided over a gathering of 104 members and guests. The ever increasing number of members attending this function indicates its growing popularity.

The principal guests included Col. Sir George Wade, who, in the course of a racy speech proposing the toast of 'The Institution of Electrical Engineers', developed the theme that the gadgets produced by electrical engineers were nothing more than a pest to mankind. The President, Sir George Nelson, who obviously enjoyed being in his home Sub-Centre again, answered Sir George Wade's challenge by detailing some of the work of The Institution and of the electrical industry which is aimed at improving living conditions.

The toast of 'Our Guests' was proposed by Mr. J. G. Wood, Hon. Assistant Secretary and Treasurer, who deputized for the Senior Vice-Chairman, Mr. A. T. Chadwick. Mr. Wood thoroughly delighted his hearers by an extremely well-delivered speech containing a quip for each guest and a joke in every sentence. For example, his pun, 'Passing from Sir George to Sir George—in some circles this is referred to as a knight-shift— . . .' was received with uproarious applause. Mr. A. M. Gamble, Headmaster of Denstone College, replied to

this toast, and in referring to the educational activities of The Institution made an appeal for greater time to be devoted to the humanities.

All the speeches maintained the high level of quality and humour which has been a notable feature of our Sub-Centre dinners.

A formal reception by the President and Chairman preceded the Dinner, and a conversazione followed it to complete a particularly happy and successful function.

London's Electricity

At the Stoke meeting on the 19th March, Dr. E. R. Patrick introduced Mr. E. J. Whitcher, who had kindly undertaken to read the paper *The Supply of Electricity in the London Area* on behalf of the author, Mr. D. B. Irving, who was unable to be present. The paper contained much material of particular interest to supply engineers, many of whom had to deal with similar problems though on a much smaller scale. The discussion was opened by Mr. L. Goodall. Mr. H. McCartney proposed a vote of thanks to the author, and to Mr. Whitcher for reading the paper and for dealing so fully with the discussion. Mr. McCartney invited Mr. Irving or Mr. Whitcher to prepare a further talk on this subject, because there was a dearth of papers dealing specifically with supply work.

The Chairman announced that Mr. J. G. Wood was shortly leaving to take up a post near London. He thanked Mr. Wood for the excellent work he had done for the Sub-Centre, particularly in organizing the various functions, and for deputizing for Mr. Chadwick at the Annual Dinner. He extended the best wishes of the members for success and happiness in his new post.

The duties of Hon. Treasurer and Assistant Secretary will be carried out by Mr. D. H. Tompsett for the remainder of the present session.

As a result of the small credit balance arising from the Annual Dance in November and the Annual Dinner, a donation of £10 10s. has been made to the Benevolent Fund. L. G.

SCOTLAND

SCOTTISH CENTRE

The Scottish Centre is unique in that the Chairman delivers his Address at the end instead of the beginning of the session, and in that he may be called upon to deliver it four times. This year's Chairman, Dr. E. Wilkinson, made the first two deliveries in Aberdeen and Dundee on the 7th and 8th March; at the second meeting Dr. Wilkinson invited Mr. T. E. Goldup, visiting the Sub-Centre in his capacity of Vice-President, to take the chair. The Address was entitled *Straw for the Bricks*, the bricks being university graduates in engineering. Dr. Wilkinson examined critically various relevant statistics, and his conclusions were, *inter alia*, that the ratio of honours to pass students is rather high (about 1·4) so that the honours standard could well be raised, and that no reduction can be afforded in the quality of graduates, e.g. through lower entry qualifications. The straw for these bricks is among the school leavers; it was shown that in Scotland there is little wastage of talent amongst those qualified to enter universities but that there is a considerable loss at the age of 15 or 16, when promising boys and girls leave school. Among several proposals for avoiding this loss a good case was made out for the employment of women in the electrical industry and, in fact, quite a glamorous picture was painted of the industry's future. Dr. Wilkinson repeated his Address in Glasgow on the 11th April and he will deliver it again in Edinburgh at the Annual General Meeting of the Centre on the 22nd May.

The Faraday Lecture was presented this year at two places in Scotland—Glasgow and Aberdeen. In both cities the Lecture was thoroughly enjoyed by large audiences; the demonstrations, including the deliberate mistakes, worked admirably and left the audiences in no doubt not only of the hazards of coal-mining but also of the extensive development work that is being carried out to ensure the more effective winning of this valuable natural material. In Glasgow the Chairman was particularly pleased to welcome among the audience Professor G. W. O. Howe, who, in 1924, delivered the first Faraday Lecture.

District Meetings have again been held at Inverness and Galashiels. At Inverness on the 16th February an audience of 96 heard Mr. A. A. Fulton read the late Mr. T. Lawrie's paper on *Highland Water Power*, the chair being taken by Mr. R. B. Anderson. At Galashiels on the 22nd March Mr. Cameron Brown read his paper on *Farm Electrification*; the chair was taken by Mr. Sankey, who welcomed Mr. W. B. Laing, Chairman of the South-East Scotland Sub-Centre, and thanked Mr. D. M. Thornton who had made the local arrangements. Both meetings were most successful and enabled members and visitors to hear about and discuss subjects of considerable local interest. E. O. T.

YORKSHIRE

NORTH MIDLAND CENTRE

It is with deep regret that we have learned of the death of Mr. S. R. Siviour, a Past-Chairman of the Transmission Section, and a Past-Chairman of the North Midland Centre. He was not only a Member of the Court of Governors of the Benevolent Fund, but also for many years the Local Honorary Treasurer of this Fund; he was also a Committee member of our Centre for many years, holding various offices. But as well as for his work for The Institution he was widely known for his professional work for over 40 years in the electricity supply industry in Yorkshire, and he will be greatly missed by his many friends there. J. L.

WEST COUNTRY

SOUTH-WESTERN SUB-CENTRE

Outside Information

Since the last report the 82nd, 83rd and 84th Ordinary Meetings have been held under the chairmanship of Mr. W. J. Guscott at Plymouth, Torquay and Exeter respectively, and a District Meeting, convened by Mr. C. H. Foulkes, has been held at Ilminster.

The average attendance at the Ordinary Meetings was sixty-eight. This figure speaks not only for the wisdom of the papers Sub-Committee but is also a measure of the keenness of the Sub-Centre's widely scattered members. The District Meeting was likewise well attended. No greater encouragement can be provided for the Sub-Centre Committee than this keen interest.

The papers read were *Transistors*, by R. A. L. Cole, *Electrical Energy from the Wind*, by E. W. Golding, and *The Electrification of the Manchester–Sheffield–Wath Lines*, by J. A. Broughall and K. J. Cook (read by Mr. A. G. Hopkin). At the District Meeting Professor H. Moore read a paper on *The Scientific and Technical Applications of Glass Technology*. All these papers invoked interesting discussions which were not without humour.

Opening the discussion on *Electrical Energy from the Wind*, Mr. W. F. Smith, of Exeter, stated that his knowledge of the subject was really confined to the design, manufacture and erection of audio-frequency generators to scare the birds from his peas. In a somewhat similar manner Mr. G. J. Websdale opened the discussion on the third paper by protesting that he was an outsider to this subject. In both instances, however, their questions provoked very instructive answers from the authors. Mr. Hopkin remarked that if there were any other outsiders present he hoped that they would not have such an inside knowledge of the subject.

The members heartily endorsed the Chairman's 'welcome back' to Mr. H. C. O. Stanbury, the immediate Past-Chairman, after his illness. At the Exeter meeting Mr. W. J. Guscott presented Mr. Stanbury with a special copy of *The History of The Institution.*

Collections made at each Ordinary Meeting for the Incorporated Benevolent Fund realized a total of £11 12s. 7d.

G. B. H.

NEWS *from Abroad*

BURMA

The 1955–56 'cold' season in Burma will long be remembered on account of the number of leading political figures who have visited the country.

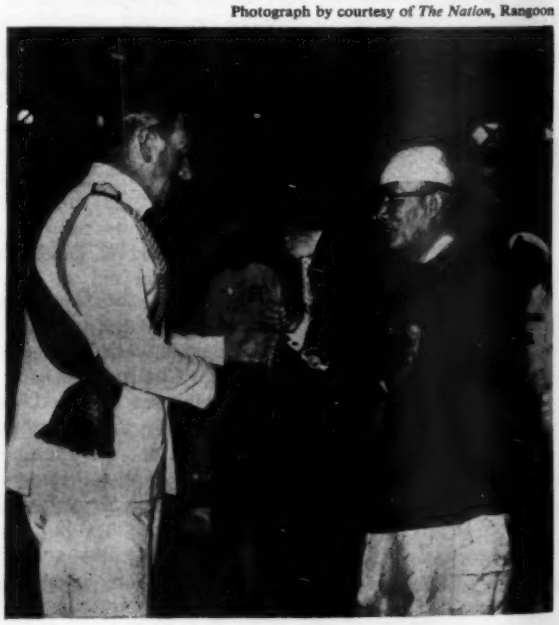
In March, Admiral the Earl Mountbatten of Burma, who is a Chartered Electrical Engineer, and Lady Mountbatten spent a few days in the country, with which they had been so closely associated during the Second World War. On the 22nd March, Lord Mountbatten was invested with the Honour of Agga Maha Thiri Thudhamma, the highest Order in Burma.

A few weeks earlier, Major-General Sir Hubert Rance—the last British Governor of Burma—had also visited the country and had been invested with the Honour of Agga Maha Thray Sithu. Sir Hubert found time to renew his earlier contact with electrical engineering when he visited the new power station of the Burmah Oil Company at Chauk.

On the 19th January, 1956, the Honourable Minister for Industry, U Kyaw Nyein, officially opened the new 5 MW Diesel power station of the Rangoon Electric Supply Board, in the presence of the British Ambassador. The plant is of British manufacture throughout, and was put into full commission 22 months after the date on which an order for the engines was placed. Erection was undertaken solely by the Board's own staff with assistance from the local agents of the engine and alternator manufacturers. It is an axiom among Diesel engineers that Diesel stations are clean enough to eat in and on this occasion lunch was served in the engine-room.

The Association of Engineers in Burma have continued

Photograph by courtesy of *The Nation*, Rangoon



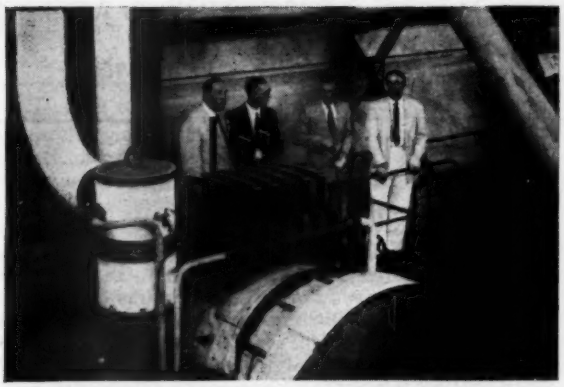
Admiral the Earl Mountbatten of Burma is invested by Dr. Ba U, the President of the Union of Burma, with the Honour of Agga Maha Thiri Thudhamma

to hold monthly meetings. Two papers of interest to electrical engineers were those on *The Role of Engineers in the Development of Atomic Energy* by Dr. Freddy Ba Hli, Acting Director, Union of Burma Atomic Energy Centre, and *The Design and Transmission and Distribution System from Pegu Hydro-Electric Station* by U Maung Maung. The latter paper, which was based on practice in the United States, gave rise to an interesting discussion among the Burmese, British and American engineers who attended the meeting. C. M. M.

OVERSEA ATTENDANCE REGISTER

During the period 1st March to 31st March, 1956, the following members called at the Institution Building and signed the Attendance Register of Oversea Members:

BARBARA, A. (Zabbar, Malta).
BOOTH, A., M.A. (Lagos).
HEELEY, F. S. (Winnipeg).
MYERS, H. E. M. (Calcutta).
RASKUTTI, D. C. (Bombay).
SAVAGE, R. A. (Kuala Lumpur).
VIGNES, J. F. (Vacoas, Mauritius).



Photograph by courtesy of *Yadana* (the Burmah Oil Co.'s house journal)

Sir Hubert Rance (extreme left) at the Burmah Oil Company's power station, Chauk

The Allocation of V.H.F. Wavebands in the United Kingdom

The Table shows the present allocation of Bands I, II and III for v.h.f. sound broadcasting and television in the United Kingdom. The B.B.C. television stations now in operation are: Crystal Palace (London), Divis (near Belfast), Holme Moss (in the Pennines near Huddersfield), North Hessary Tor (South Devon), Isle of Man (temporary), Kirk o'Shotts (between Glasgow and Edinburgh), Rowridge (Isle of Wight, temporary), Norwich (temporary), Sutton Coldfield (near Birmingham), Meldrum (near Aberdeen), Channel Islands (experimental), Wenvoe (near Cardiff) and Pontop Pike (near Newcastle upon Tyne).

The B.B.C. has applied for channels in Band III for its second television programme, but the Postmaster-General has deferred for two years any decision on this.

The chart does not show Bands IV and V, which extend from 470–585 and from 610–960 Mc/s respectively. These will later be divided into television channels, but their number and allocation is not yet decided.

B.B.C. v.h.f. sound-broadcasting stations at present in operation are Wrotham (Kent), Penmon (Anglesey, temporary), Wenvoe (part completed), Pontop Pike, Divis and Meldrum.

Band-width Mc/s	Allocation	Stations in operation or planned	Remarks
41–68	**Band I** B.B.C. television	Channel 1 Crystal Palace, Divis. 2 Holme Moss, N. Hessary Tor, Rosemarkie,* Londonderry.* 3 Kirk o'Shotts, Rowridge, Norwich, Blaen Plwy. 4 Sutton Coldfield, Meldrum, Carlisle,* Channel Isles. 5 Wenvoe, Pontop Pike, Isle of Man.	17 B.B.C. television stations, designed to serve 98% of the population of the United Kingdom, will be accommodated in Band I.
68–87·5	Fixed and mobile communication services and aeronautical radio navigation.		
87·5–100	**Band II** Sound	Stage 1. Wrotham, Penmon,† Wenvoe, Norwich,* Pontop Pike, Divis, Meldrum, N. Hessary Tor,* Sutton Coldfield,* Blaen Plwy,* Holme Moss.*	The B.B.C. plans some 25 v.h.f., f.m. broadcasting stations carrying Light, Home and Third Programmes to 98% of the population.
		Non-broadcasting services above 95 Mc/s—fire, police, ambulance.	
100–174	Fixed and mobile communication services and aeronautical radio navigation.		
174–216	**Band III** Television	Channels 6–13 Channel 8 I.T.A. Midlands. 9 I.T.A. London, Lancashire. 10 I.T.A. Yorkshire*	

* Not yet in operation. † Temporary.

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MONOGRAPHS

The Continuous Delay-Line Synthesizer as a System Analogue

MONOGRAPH No. 176 M

J. H. WESTCOTT, B.Sc.(Eng.), Ph.D.

The use of a continuous delay-line synthesizer as a means for simulating transfer functions of linear systems by a very simple setting procedure is described. An analysis of the accuracy of this device as a system analogue is given, and the degree of approximation in frequency response is calculated for a number of transfer functions typical of servo systems.

Properties of a Feedback-System Analogue based on a Discontinuous Delay-Line Synthesizer

MONOGRAPH No. 177 M

R. M. F. HOUTAPPEL

The paper studies the frequency response of a feedback-system analogue, in which the system is imitated by a discontinuous delay-line synthesizer.

The various sources of error in the imitation transfer functions of the delay-line synthesizer and stabilizing network, as compared with the actual transfer functions of the system and stabilizing network, are discussed. The contribution of each of these sources is calculated for a feedback system consisting of a multi-capacity process and a three-term controller. The results of these calculations are used to find out how to minimize each of these contributions.

The Application of the Frequency Response Method to Electrical Machines

MONOGRAPH No. 178 S

S. K. SEN, B.E., and B. ADKINS, M.A.

The frequency-response method is well established in the analysis of control systems and networks, but has hitherto not been extensively used for analysing rotating machines. The method is of particular value when the magnetic circuit of the machine contains unlaminated iron in which eddy currents are set up when the flux changes. The paper describes a method of calculating the performance of the machine, and shows how the effect of the eddy currents can be allowed for.

The investigation was carried out by considering first a simple iron ring with a toroidal winding, then a d.c. machine, and finally a turbo-alternator. For these three examples several methods of calculating the appropriate frequency-response curves have been worked out and verified by means of tests. The application of the frequency-response curves to determine the performance characteristics is illustrated by calculations and tests made for several simple transient conditions.

Microwave Measurements with a Lossy Variable Termination

MONOGRAPH No. 179 R

H. M. ALTSCHULER, M.E.E., and PROFESSOR A. A. OLINER, Ph.D.

The use of a lossy variable termination becomes an undesirable necessity in certain measurements, while in others its deliberate use facilitates the measurement of low-loss structures. In both cases the present approach permits the analysis of the data to proceed in a manner identical to that employed when lossless short-circuits are used, i.e. with already familiar procedures. It results in a composite 4-terminal network from which the desired parameters are separated with particularly simple relations.

Applications are made to a variety of measurements, including those of dissipative, lossless and symmetric 4-terminal networks, attenuation and attenuation coefficients.

PAPERS

The Automatic Solution of Power-System Swing-Curve Equations

PAPER No. 2035 S; PART A

C. ADAMSON, M.Sc.(Eng.), L. BARNES, M.Sc.Tech., and B. D. NELLIST, M.Sc.Tech.

The paper details the problem of transient stability in electrical power systems and divides the methods used to date into four categories. These categories, with the relevant literature, are briefly reviewed.

The paper then describes the theory, method of construction and mode of operation of an automatic step-by-step computer for power-system swing curves; the machine has facilities for two generators only but may be extended in scope by the addition of similar equipment to that already employed. The limitations of this machine are discussed and a direct-analogue method for use with the generator units of a network analyser is then described.

SOME RECENT BOOKS

J. R. MENTZER

SCATTERING AND DIFFRACTION OF RADIO WAVES

LONDON AND NEW YORK: PERGAMON PRESS. 142 PP. 30S.

This volume is the seventh of a series of monographs on *Electronics and Waves* published under the general editorship of D. W. Fry. The monographs are written by specialists in their own subjects, and it is the aim to keep abreast of the rapid progress which is being made in the field of electronics and applied physics. The volume here under review is intended to provide research workers with a concise account of the present state of knowledge concerning the methods available for determining the manner in which obstacles scatter and diffract radio waves. Interest in these matters has increased considerably in recent years, particularly in so far as they are important in the study of radar performance and the design of large and complex aerial systems; and the book has been written primarily with such topics in mind.

The latest mathematical methods for the calculation of scattering, especially back-scattering, cross-sections of various objects, and a brief review of the well-known classical methods of solution are included in order to provide a continuous and self-consistent treatment. The author deals with many aspects of the subject about which little has been published to date. Examples of the problems considered in detail are: scattering by finite cylinders, cones and paraboloids, diffraction by small apertures, and the tensor treatment of scattering by curved surfaces. The vector variational principle for scattering is also discussed and exemplified.

The solutions of several of the most important problems involving types of object of particular interest to radar workers are given. It is evident, however, that the determination by theoretical means of the resultant field around a scattering object in a given incident field is frequently very difficult. This is particularly true of some of the most interesting practical cases, where the surface of the object cannot be described by a complete geometric co-ordinate surface, and an experimental approach is then often helpful. For this reason the author describes, in the last chapter of the book, the principles underlying modern techniques for the measurement of scattered and diffracted fields. The possibilities of experiments with scale models are outlined, and the relative advantages and disadvantages of continuous-wave and pulsed radar systems for measurement purposes are discussed. A useful table of formulae for the calculation of radar cross-sections for certain objects of appropriate shape is given in an appendix.

The book is clearly and concisely written, and there is an excellent list of references to supporting literature. It should be useful not only to advanced students of physics and electrical engineering, but also as a reference book for research workers concerned with electromagnetic boundary problems.

T. R. SCOTT

TRANSISTORS AND OTHER CRYSTAL VALVES

LONDON: MACDONALD AND EVANS. 274 PP. £2 5S.

Physicists discovered and explained the mechanism of transistors; backed by chemists, metallurgists and some electrical engineers, they have, in seven years of increasing activity, prepared the way for the transistor to become a very important component in electronic engineering. Many electrical engineers to whom the transistor has so far been little more than a novelty must expect to see it entering their provinces. To make the best use of it they must learn something of its design and technology and much of its properties, possibilities and limitations.

The author recognizes the needs of the engineers and has written his book to meet it. He has tried to encompass some of the research and much of the development of the seven years, and, when one cannot be sure of the relative importance of the different parts, that is no simple task. He follows his introduction, which is largely historical but contains too many disjointed facts, with a chapter on crystal imperfections and the properties of the two important transistor materials, germanium and silicon. A chapter on *p–n* junctions introduces junction diodes and transistors, largely in qualitative terms, after which point-contact diodes and triodes receive attention, with emphasis on forming. The author considers the influence of temperature and then describes applications, circuit techniques and testing. Here, engineers might well have expected something analytical, quantitative and generally more detailed. A very good chapter on h.f. transistors precedes one on the choice of semi-conductors. There are appendices on the band structure of semi-conductors and on testing techniques. A lengthy bibliography includes many references of far more interest to chemists and physicists than to engineers; nevertheless nearly all the important pre-1955 articles on transistors are included.

The book suffers from several faults. Many facts are included but few are emphasized. Some quantities are introduced but never adequately explained, e.g. *surface-recombination velocity* and *turn-off time*. There are mistakes or misleading statements; the multiplication of two terms, instead of their addition, in the expression (18) for the saturation current of a *p–n* junction might have been excused as a printing error, had it not been subsequently used on page 120, fortunately not with serious results. The capacitance of alloy *p–n* diodes is not described well. The author is repeatedly optimistic about the point-contact transistor, suggesting that it is cheaper to make than a junction transistor, a fact difficult to reconcile with current trends, if making includes consistency and reliability. He favours the double-surface coaxial type.

The book can be read with interest by those who already have a good grounding in the subject, but it cannot be recommended either as a primer for engineers or as a reference book. The paper used is poor and some of the Figures are over reduced, but the type is good.

F. E. TERMAN and others

ELECTRONIC AND RADIO ENGINEERING

NEW YORK: McGRAW-HILL. 4TH EDITION. 1085 PP. £3 11S. 6D.

It is nearly twenty-five years since the first edition was published under the title 'Radio Engineering'. This fourth edition of over a thousand pages is the combined work of five members of the staff of Stanford University, where Professor

Terman is Dean of the School of Engineering. In keeping with the change of title a great amount of new material has been added and more than half the illustrations are new, but the standard of treatment has not been changed; it is still such that it can be readily understood by undergraduate students. An entirely new chapter has been added dealing with microwave tubes, explaining in simple language the basic mechanism of travelling-wave tubes and backward-wave oscillators. After a short introductory chapter the book is divided into three parts. The first consists of four chapters dealing with circuit elements and theory, transmission lines, waveguides and cavity resonators. Then follows the main part consisting of sixteen chapters entitled 'Electronic Engineering Fundamentals', and dealing with the various applications of electron tubes and valves. It concludes with a 70-page chapter on transistors, with the emphasis on the junction type, the purpose being 'to introduce the basic phenomena of semiconductors . . . in simple words that give a clear and accurate semiquantitative understanding of these devices'. The final section of five chapters is entitled 'Radio Engineering and Radio Systems'; it deals with propagation, antennae, transmitters, receivers, television and radar. Each chapter concludes with a large number of problems and exercises, the total number exceeding 1 250, so that, as the authors claim, the same problem need not be used in a class more often than once every two or three years. In footnotes throughout the book nearly 500 references are given to other publications, and an index of the authors' names is given at the end.

As an example of the general line of approach to the various branches of the subject we may quote the introductory footnote to the 70-page chapter on antennae. 'There have been so many developments during recent years in the theory and practice of radio antennas that this chapter is necessarily confined to a consideration of general principles illustrated by a few examples. For further information on the subject . . . the reader is referred to . . .'. Then there follows a list of seven books on the subject.

The treatment throughout is very clear and concise and well illustrated; the mathematics does not go beyond the level which is essential for a clear understanding of the phenomena involved and the operation of the devices under consideration. The book can certainly be recommended to advanced students and qualified engineers both as a textbook and as a book of reference.

OBITUARY

FRANCIS GEORGE CASTER BALDWIN

Francis George Caster Baldwin, O.B.E., who died on the 12th January, 1956, was born at Sheffield on the 11th October, 1878. He received his education at Barnsley, and later at the Sheffield Technical School. In 1895 he entered the employment of J. Nash and Sons, Inspecting and Testing Engineers at Sheffield, as a clerk. The following year he joined the National Telephone Co. as a draughtsman, and after three years he was appointed Engineering Inspector at Sheffield, where he carried out large extensions of the underground telephone system. During this time he attended Sheffield University College and passed four electrical engineering examinations with distinction, gaining three first prizes. Subsequently he became a lecturer and demonstrator in evening classes in electrical engineering at the same college.

In 1906 he was appointed District Engineer for Birmingham, and in 1909 he was promoted Assistant Metropolitan Engineer in London, with the task of preparing an inventory of the company's plant.

Shortly after the acquisition of the National Telephone Co. by the State in 1912, he was appointed Executive Engineer of the City External Section of the London Post Office Engineering District, and a year later he became Assistant Superintending Engineer of the Post Office Northern District.

In 1931 he was promoted to Superintending Engineer in Newcastle, and finally, in 1935, became Chief Regional Engineer of the North-Eastern Region of the Post Office, with headquarters at Leeds, where he remained until his retirement in 1938, when he was made an O.B.E.

His special studies included scientific organization, and in this connection he was able to introduce certain improvements in the Post Office. He was a very sound man, and extremely well liked by all who knew him. He spent some time in research into the history of the telephone, and in 1935 published a book, 'The History of the Telephone in the United Kingdom'. He had many hobbies and interests—geology, photography, gardening, painting, music and history—and in his retirement he was able to enjoy these. He is survived by his daughter and two sons.

Mr. Baldwin joined The Institution as an Associate in 1904, and was elected an Associate Member in 1906 and a Member in 1919. In 1920–21 he served as Vice-Chairman, and in 1922–23 as Chairman, of the North-Eastern Local Centre Committee, and continued to serve as a member of the committee from 1925 to 1928 and again from 1930 to 1936. In 1909 a paper by him on 'Some Considerations in the Manipulation of Dry Core Telephone Cables' was published in the *Journal*, and in 1918 he read a paper entitled 'Telephone Exchange Transfers and their Organization', for which he was awarded the Fahie Premium by The Institution.

A. G. L.

NORMAN CRESSY BRIDGE

Norman Cressy Bridge, who died on the 7th November, 1955, was born on the 2nd September, 1883. He was educated at Streatham Grammar School and Cranleigh School, Surrey, and received his technical education from 1899 to 1901 at Finsbury Technical College, where he obtained a Certificate in Electrical Engineering in the latter year.

He started his professional career with practical construction and operation work with the Newcastle upon Tyne Electric Supply Co., the North Eastern Railway Co. and the Yorkshire Electric Power Co. at Leeds. He joined the firm of Strain and Robertson, Glasgow consulting engineers, in 1907, first as an Electrical Assistant then as a partner (in 1916) and senior partner (in 1929).

For practically the whole of his life, Mr. Bridge was actively engaged in electric power generation, and among the more important power schemes on which he was engaged as consulting engineer were the Clyde's Mill and Yoker generating stations of the former Clyde Valley Electrical Power Co. (now the South of Scotland Electricity Board). He also

acted in an advisory capacity with regard to the Lanarkshire water-power stations.

Mr. Bridge was a man of great integrity and sincerity. He had a deep sense of responsibility, and no matter of detail was too insignificant for his personal attention. He was always courteous and willing to give help and guidance to his staff and friends, by whom his loss will be keenly felt.

Mr. Bridge joined The Institution as a Student in 1901 and was elected an Associate Member in 1909 and a Member in 1917. He served on the Committee of the Scottish Centre from 1926 to 1929 and from 1932 to 1937, and was Chairman of the Centre in 1933–4. He was the author of two papers published in the *Journal* in 1909 and 1934. He was also a member of The Institution of Mechanical Engineers. J. J.

ROBERT ANTONY HARVEY

Robert Antony Harvey, B.SC.(ENG.), who died on the 9th March, 1956, was born on the 21st November, 1906. He was educated at Lavender Hill School, Battersea, and at Sir Walter St. John's School, Battersea, and received his technical training at Battersea Polytechnic from 1925 to 1928, gaining the B.Sc.(Eng.) degree of London University with first-class honours.

He obtained practical experience as a college apprentice with Metropolitan-Vickers Electrical Co., Manchester, from 1928 to 1930. In 1931 he was appointed an assistant engineer at the Chloride Electrical Storage Co. (later Chloride Batteries Ltd.), at Clifton Junction, and remained with this firm for the rest of his working life. He had, in fact, just completed 25 years' service with the company on the day of his death. His responsibilities, under the Chief Engineer, included certain of the engineering aspects of inquiries and contracts for all kinds of charging plant for batteries used for emergency lighting and in generating stations and substations.

For many years he was a part-time lecturer at the Royal Technical College, Salford, and in 1953 he published a book entitled 'Battery Chargers and Charging', which is becoming accepted as a standard work on the subject. He leaves a widow and three children.

Mr. Harvey joined The Institution as a Graduate in 1929, and was elected an Associate Member in 1936 and a Member in 1954. He was the author of a paper on 'The Automatic Control of Lead-Acid-Battery Charging Equipment', which he read before The Institution in 1949. E. R. S.

PHILIP LYLE RIVIERE

Philip Lyle Riviere, who died on the 20th October, 1955, was born on the 26th August, 1874. He received his technical training at St. Andrews University (Dundee College), and became an apprentice first at George Wailes and Co. in Euston Road, and afterwards at the Swindon Works of the Great Western Railway. He spent two years as Works Manager of the Kuma Co.

In 1901 Mr. Riviere joined the staff of Kennedy and Jenkin as Assistant Engineer, and took part in the design and erection of many electrical-power, lighting and tramway installations all over the country including Edinburgh, Oldham, Kirkcaldy, the first installation of the L.C.C. conduit tramways and the large aluminium works at Kinlochleven.

He was concerned with the erection of the generating station at Horseferry Road for the Westminster Electric Supply Corporation and afterwards spent some years in Calcutta engaged in the erection of a new generating station and substation, and the laying of a 30 000- and 6 600-volt network—one of the very first extra-high-voltage cable systems laid.

In 1917 Mr. Riviere was appointed Chief Engineer of the L.C.C. Tramways, and held that office during a period in which many labour disputes occurred. He took an active part in the famous Award 2772 (the Sparks Award) and the work of the first London District Council for the electricity supply industry.

He resigned his position with the L.C.C. in 1926 and succeeded his old chief, Sir Alexander Kennedy, as Engineer-in-Chief of the Westminster Electric Supply Corporation. He was entirely responsible for taking the decision to change the d.c. system to the standard a.c. system and, more remarkable still at that date, decided to adopt a 'solid' 3-phase 4-core l.v. system.

In 1936, when the London Associated Electricity Undertaking (later Central London Electricity Ltd.) was formed, he became their first Engineer-in-Chief, and did great work in the formation of the engineering branch from the engineering staffs of six constituent companies.

Mr. Riviere retired on the 26th August, 1940. Apart from his outstanding qualities as an engineer, he was an experienced mountaineer, and was extremely good at skating, golf (he was a founder member of the Engineering Golfing Society), billiards, and in earlier days, lawn tennis; he did all things much better than the average man. But his greatest interest in life was to plan for the future. He was always willing to extend a helping hand to his staff, and had that remarkable ability to inspire the greatest loyalty in those he controlled. He was a great and kindly man of very wide vision.

He joined The Institution as a Member in 1911, and served as a Member of Council from 1937 to 1940. L. H. W.

ARTHUR HENRY SHORT

Arthur Henry Short, who died on the 8th November, 1955, was born on the 17th August, 1893. He received his early education at a school in Edmonton, Middlesex, and his practical training at the Edison Swan Electric Co. from 1909 to 1911, during which time he attended evening classes in general engineering. In 1911–12 he was the assistant to the electricity instructor at the School of Engineering, Poplar, and was subsequently employed in various electrical firms, until in 1914 he joined the staff of Nobels Explosives Co., Waltham Cross, and stayed with that company for seven years. During this time, from 1916 to 1918, he furthered his education by means of a correspondence course in electrical engineering, and in 1919 was appointed Deputy Works Electrical Engineer.

In 1921 he moved to Somerset, where he was to live for the rest of his life, and took up the post of Engineer and Manager of the Burnham Electric Supply Co., Burnham-on-Sea. Three years later he joined the Minehead Electric Supply Co., as Chief Engineer and Manager. When, in 1937, the Whitehall Securities Corporation acquired an interest in that company, he also took control of the Wellington District Electric Supply Co. On the nationalization of the electricity supply industry in 1948, Mr. Short was appointed Manager of the Minehead District of the South Western Electricity Board, and continued in that post up to the time of his death. During his long association with the electricity supply industry he was responsible for many developments, such as the change from

3-wire d.c. supply to 3-phase 4-wire supply, and he was a pioneer of the extension of rural supplies.

In his younger days Mr. Short was a fine swimmer and won a number of championships in the London area. He was devoted to Minehead and the surrounding countryside, and was often to be seen taking the sea air on the promenade, or the more bracing air of his favourite North Hill. He enjoyed extremely good health until 1953, when both he and his wife suffered from a severe attack of pneumonia, from which he never fully recovered. He continued in his duties, however, until the end, so that his death came as a great shock to his many friends. He was a quiet, reserved but kindly man, and, as expressed by a member of his staff, 'The Minehead staff feel they have lost a real friend'. He is survived by his widow and one son.

Mr. Short joined The Institution as a Graduate in 1919, and was elected an Associate in 1929, an Associate Member in 1939 and a Member in 1944. F. P. F.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

HOLZBOCK, W. G. 681.2

Instruments for Measurement and Control*

New York, Reinhold, 1955. pp. vi, 371. 23 × 16 cm. £4.

Describes remote indicating instruments for measuring temperature, humidity, pressure, flow, liquid level, density, viscosity and speed. Gives a schematic diagram of the method of operation and other particulars of instruments commercially available in the United States.

JELLINEK, S. 612:621.3

Atlas zur Spurenkunde der Elektrizität (Morphological survey of the effects of electric currents)

Vienna, Springer-Verlag, 1955. pp. viii, 78. 25 × 17 cm. About £7.

A collection of photographically recorded observations of damage caused by high voltage or lightning to both living and non-living matter. They reveal certain definite patterns which will be of interest to the physicist and the medical man. The author has made no attempt to interpret the results he has obtained.

JONES, Sir Harold Spencer (Compiler) 550.389

Sunspot and Geomagnetic-Storm Data Derived from Greenwich Observations 1874–1954

London, H.M.S.O., 1955. pp. viii, 106. 30 × 25 cm. 25s.

KAISER, T. R. (Editor) 523.5

Meteors. Special supplement (Vol. II) to the Journal of Atmospheric and Terrestrial Physics

London, Pergamon Press, 1955. pp. vii, 204. 25 × 17 cm. £2 15s.

Papers published in this volume were presented at a symposium on meteor physics held at the Jodrell Bank Experimental Station in July, 1954. A number of the papers deal with the effects of meteors on radio propagation.

KOPAL, Z. 518.5

Numerical Analysis. With emphasis on the application of numerical techniques to problems of infinitesimal calculus in single variable

London, Chapman & Hall, 1955. pp. xiv, 556. 23 × 15 cm. £3 3s.

An advanced undergraduate textbook on the application of numerical processes to the solution of problems of infinitesimal analysis encountered in physics and engineering which are not amenable to solution by formal analysis.

KURTZ, E. B. 621.315

The Lineman's Handbook*

3rd ed. New York, McGraw-Hill, 1955. pp. 776. 21 × 14 cm. £3 4s.

A practical work which describes materials, equipment, circuits, tools and methods used in American overhead-line installation and maintenance practice.

LEY, W. 621

Engineers' Dreams*

London, Phoenix House, 1955. pp. x, 192. 21 × 13 cm. 15s.

Describes a number of large engineering projects which although practical have not been undertaken because of political or financial considerations. These include the Channel tunnel, floating aerodromes, hydro-electric and irrigation schemes and tidal-power plans. Other undertakings such as 'Pluto' and the use of natural hot water and steam are also described.

McCOMBE, J. 621.315.1

Overhead Line Practice*

2nd ed. London, Macdonald, 1955. pp. x, 287. 22 × 14 cm. 25s.

A practical and comprehensive survey of overhead-line practice and construction taking account of B.S. 1320: 1946. Includes the survey, planning and preparation of routes, the associated legal negotiations, materials and accessories, and statutory conditions, such as those relating to adjacent telephone circuits. This edition has a chapter on maintenance and testing of overhead lines and there is an extension to the chapter on sag-tension calculations.

MENTZER, J. R. 621.396.11

Scattering and Diffraction of Radio Waves*

London, Pergamon Press, 1955. pp. viii, 134. 22 × 14 cm. 30s.

This is not an elementary book and a knowledge of electromagnetic theory and some facility with the calculus is assumed. It deals with the mathematical formulation of two- and three-dimensional scattering problems, and then discusses measurement, particularly the measurement of radar cross-sections. This book is reviewed on p. 301.

PEEK, R. L., Jnr., and WAGAR, H. N. 621.318.5

Switching Relay Design*

Princeton, Van Nostrand, 1955. pp. viii, 478. 24 × 16 cm. £3 10s.

This book is based on training courses in relay design given at the

Bell Telephone Laboratories. It deals with mechanical requirements—contacts, springs and electromagnets, with operation and release times, and with other questions of relay design. The determination of the characteristics of relays and the design of relays to give a specific performance are described. This book will be reviewed in a future issue.

PENMAN, H. L. 533.27

Humidity

London, Institute of Physics, 1955. pp. 71. 18 × 12 cm. 5s.

Suitable for students for the Higher National Certificate in applied physics. Discusses atmospheric humidity and vapour pressure, and the physical principles of vapour-liquid equilibrium. The various types of hygrometer and some special devices are described. Humidity control for industrial purposes is discussed.

RECORD, P. D., and WHITROW, M. (Editors) 014:043

Index to Theses Accepted for Higher Degrees in the Universities of Great Britain and Ireland. Volume II 1951–52

London, Aslib, 1955. pp. xii, 175. 24 × 15 cm. 21s.

A considerable amount of original work and research is described each year in theses, but in the past it has been difficult to discover what information of this kind existed. This is the second of a series of annual volumes which give the author's name, the university, the title of the thesis and the degree for which it was accepted.

SMYTH, C. P. 537.226

Dielectric Behaviour and Structure. Dielectric constant and loss, dipole moment and molecular structure

New York, McGraw-Hill, 1955. pp. x, 441. 24 × 16 cm. £3 7s. 6d.

Discusses the fundamental theories of dielectrics, considers the interpretation of dielectric constant and loss data in terms of structures, and describes methods of measurement. Experimental results on a great number of liquids and solids are discussed in detail, including glasses, high polymers, ferro-electrics and electrets.

SWALUW, H. L., and WOERD, J. VAN DER 621.397.62

Introduction to TV Servicing (for 625 and 525 Line Receivers)*

Eindhoven, Philips Technical Library, 1955. pp. viii, 624, 3 charts. 21 × 15 cm. £2.

Gives a detailed description of how the stages of a television receiver work. Describes the simple portable test instruments for servicing a receiver in the customer's home. Typical faults are indicated by pictures of test cards and their remedy explained. Although based on Philips receivers the explanations are reasonably general.

THOMASON, J. G. 621.395.645

Linear Feedback Analysis*

London, Pergamon Press, 1955. pp. x, 355. 22 × 14 cm. £2 15s.

An analytical approach to the subject using practical designs from nuclear physics instrumentation, and radar equipment as illustrations. Deals mainly with the stability of the feedback loop and causes of instability, and the analysis and design of networks intended to stabilize a loop. Intended for graduates concerned with research. This book was reviewed in the March Journal.

THOMSON, Sir George 50

The Foreseeable Future*

Cambridge, University Press, 1955. pp. vii, 166. 17 × 13 cm. 10s. 6d.

Considers probable technological developments a hundred years hence in power generation, transport and communication, the control of climatic conditions and the production of food. Some possible biological developments in animal breeding, and in medicine are suggested, and, in a chapter on social consequences the author considers briefly the impact on employment, education and leisure.

TOPPING, J. 519.2

Errors of Observation and Their Treatment

London, Institute of Physics, 1955. pp. 119. 18 × 12 cm. 5s.

A book for students taking the Higher National Certificate Courses in Applied Physics. Discusses the nature and estimation of errors, the statistical ideas involved and the theory of errors. The mathematical treatment throughout has been kept as simple as possible.

TOWNES, C. H., and SCHAWLOW, A. L. 535.34

Microwave Spectroscopy

London, McGraw-Hill, 1955. pp. xviii, 698. 24 × 16 cm. £4 14s.

The microwave spectroscopy of gases has yielded information useful in such fields as nuclear physics, molecular structure, chemical kinetics, quantum electrodynamics, and astronomy. This book gives an account of the theory, and experimental data and knowledge of the subject. It gives a general account of microwave phenomena and techniques, discussing in detail those which are of particular application in microwave spectroscopy.

WENTWORTH, J. W. 621.397.3

Color Television Engineering*

New York, McGraw-Hill, 1955. pp. xix, 459. 24 × 16 cm. £3.

Intended for engineers and technicians familiar with monochrome television. It deals first with colour perception and the reproduction of colours by different processes, then explains the principles of various systems of transmitting and receiving colour television. The explanations are easy to follow and are extensively illustrated with schematic and block diagrams. This book will be reviewed in a future issue.

Liber Amicorum (Prof. J. C. van Staveren) 621.31

The Hague, Moorman's Periodieke Pers N.V., 1955. pp. 283. 25 × 17 cm.

A volume commemorating Dr. van Staveren's 25 years as Professor of Electrotechnics at the University of Utretcht. Various contributors have surveyed the field of Dutch electrical societies, the generation and use of electricity in Holland and Professor van Staveren's association with the industry.

OTHER PUBLICATIONS

BRITISH ELECTRICAL POWER CONVENTION

Proceedings of the Seventh British Electrical Power Convention, Brighton, 27th June to 1st July, 1955

Northampton, Lea and Co., 1955. pp. lxxi, 524. 22 × 15 cm.

INTERNATIONAL SCIENTIFIC RADIO UNION

Proceedings of the XIth General Assembly held in The Hague from August 23rd to September 2nd, 1954. Vol. 10. Part 6. Commission VI on Radio Waves and Circuits

Brussels, U.R.S.I., 1954. pp. 140. 24 × 16 cm.

JERENCSIK, A. P., and OTHERS

A Preliminary Investigation of the Possibilities of Expansion of Railroad Electrification in the United States. A report to the Supervisory Committee of the Joint Committee on Railroad Electrification.

New York, Edison Electric Institute, 1952. pp. 59. 28 × 22 cm. 7s. approx.

PENNSYLVANIA STATE UNIVERSITY

Proceedings for Engineering Seminar on Electrical Contacts, June 28–July 2, 1954. Parts I and II

Pennsylvania State University. 1954. 28 × 21 cm. £3 8s. approx.

TECHNICAL PUBLICATIONS

BRITISH STANDARDS AND CODES OF PRACTICE

The Secretary has been asked to draw attention to the following publications, copies of which can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given are post free.

Varnished Cambric Insulated Cables for Electricity Supply (B.S. 608: 1956). 6s.

This revision of B.S. 608 deals with (i) taped and braided, (ii) lead- or lead-alloy-sheathed and (iii) aluminium-sheathed cables. They are for working voltages up to 11 kV. It includes 'quality' clauses governing the composition of the various components of the cable. As in other recently revised Standards for power cables, the basic reference temperature is now 20° C and 'nominal' diameters are specified instead of maximum and minimum diameters.

Contactors when Supplied Separately or in Combination with Other Gear (B.S. 775: 1956). 5s.

Major changes have been made to the previous edition of this Standard, which was first published in 1938. It applies to electromagnetically and electro-pneumatically operated contactors, and covers air-break and oil-break contactors for voltages up to 11 kV a.c. and 650 volts d.c. The capabilities of contactors have now been specified in terms of various parameters, including the current rating, mechanical duty, and making and breaking category. In addition, certain more onerous requirements have now been recognized and the testing procedure has been standardized and extended.

Flexible Trailing Cables for Quarries and Metalliferous Mines (B.S. 1116: 1956). 6s.

This Standard is a revision of the 1943 edition, the three parts of which have been combined. The main new features are the inclusion of 6·6 kV cables, required for the larger machines now in use, and the incorporation of composition and test requirements for rubber insulation and for natural rubber and polychloroprene sheaths by reference to B.S. 7. The Standard does not include collectively or individually screened cables, for which reference should be made to B.S. 708.

Polyvinyl Chloride Insulated Cables and Flexible Cords for Electric Power and Lighting (for Working Voltages up to 250 Volts) (B.S. 2004: 1955). 6s.

Apart from changes resulting from the introduction of tinned conductors, such as the inclusion of a tinning test, and a few corrections, the text is the same as that of the 1953 edition.

The Performance of Power Transformers (Not Exceeding 2 kVA Rating) for Radio and Allied Electronic Equipment (B.S. 2214: 1955). 3s.

This Standard covers general-purpose power transformers (of up to 2 kVA rating) for operation at frequencies of up to 3 kc/s, and which are intended for use in radio and electronic equipment. It applies to open, enclosed, non-sealed and hermetically sealed transformers, but vibrator and pulse types are excluded. Electrical and mechanical tests are specified, but not tests at low atmospheric pressure; transformers made to the Standard may not, therefore, be suitable for use in aircraft. Further, the transformers will not necessarily meet all the requirements of the services.

Colour Codes for Connections in Radio and Allied Electronic Equipment (excluding Telephone Exchange and Associated Transmission Equipment) (B.S. 2311: 1955). 2s. 6D.

The Standard recommends two forms of colour coding. First, differently coloured wire coverings or coloured markings may be used for the connections to the various electrodes of electronic valves and tubes, with the addition of other colours to denote certain general circuit positions. Secondly, each wire may be given a different number or numbers, indicated by means of coded coloured rings, to identify it as a particular wire or to identify the two points in the circuit to which the wire is connected.

Mains-Operated Electric Fence Controllers (B.S. 2632: 1955). 3s. 6D.

Since the issue in 1945 of B.S. 1222, 'Battery-Operated Electric Fences', experience in Europe and America has indicated that mains-operated fence controllers may be advantageous in some circumstances.

The present Standard applies to devices designed for operation from either single-phase a.c. or d.c. supply mains in which the declared voltage between conductors exceeds 30 volts a.c. or 50 volts d.c. and does not exceed 250 volts. Requirements are given for construction, performance, testing, and marking.

Class I Metal Arc Welding of Steel Pipelines and Pipe Assemblies for Carrying Fluids (B.S. 2633: 1956). 10s.

This Standard covers the shop and site metal-arc welding of steel pipelines and pipe assemblies for carrying fluids suitable for Class I conditions and in sizes up to 24 inches diameter. It covers all types of butt joints, branches and sleeve welds, in addition to qualifying tests for welders. The appendices give recommendations for the method of preparation for macro-etching and the examination of completed joints by non-destructive methods.

General Requirements for the Metal-Arc Welding of Medium Tensile Weldable Structural Steel to B.S. 968 Type a (B.S. 2642: 1955). 6s.

Details are given of the materials to be used and the design of butt and fillet welds, together with illustrations. Further sections deal with fabrication, qualification and testing of welding operators, supervision and inspection, and heat treatment and testing. Graphs are included for the determination of intermediate values of plate thickness and varying degrees of preheat for rutile and low-hydrogen electrodes for use with both butt and fillet welds.

Glossary of Terms relating to the Performance of Measuring Instruments (B.S. 2643: 1955). 3s.

The definitions in this glossary have been designed, as far as possible, to cover instruments of a wide variety, and no attempt has been made to define particular types of instrument or terms associated with particular types of accuracy. The glossary is divided into three sections—design details; calibration and graduation; and sensitivity and accuracy. It includes introductory notes which draw the essential distinctions between different classes of instrument.

Tests for Use in the Approval of Welders. Part 1. Manual Metal Arc and Oxy-acetylene Welding of Mild Steel and Low Alloy Steel Sheets, Plates and Sections (B.S. 2645. Part 1: 1955). 12s. 6D.

This Standard makes available a series of standard tests, one or more of which can be selected for assessing or testing the capabilities of a welder. It is complementary to B.S. 1295, 'Tests for Use in the Training of Welders'.

Cord-Operated Ceiling-Switches (B.S. 2652: 1955). 2s. 6D.

Cord-operated ceiling-switches may be of either the surface mounting or semi-recessed type. In Section 1 definitions of the various types of switch are given. Section 2 gives the constructional requirements which apply to all switches for domestic and similar purposes, and also specifies the special requirements for the action and attachment of the operating cord. Section 3 specifies the tests required, including type tests. The electrical tests include current-carrying capacity, endurance, over-voltage and over-current capacity and high-voltage tests.

Register of Colours of Manufacturers' Identification Threads for Electric Cables and Cords (P.D. 2379: 1956). 2s.

A scheme for allocating distinctive combinations of coloured identification threads to manufacturers of electric cables in the British Commonwealth has existed for some years. The administration of this scheme was transferred from the Ministry of Defence to the British Standards Institution in 1950 and three editions of the register have since been published in mimeographed form. The fourth edition, which is now available, has been printed, and contains some notes on the extent and limitations of the scheme, the object of which is to provide a convenient means of identifying the manufacturer of a length of cable by the colours of the identification threads included in it. The register gives alphabetical lists of participating cable makers in the United Kingdom and other Commonwealth countries and an alphabetical list of colour combinations so that the manufacturer of a particular sample can be readily identified.

E.R.A. REPORTS

The Secretary has been asked to draw attention to the undermentioned E.R.A. Reports. Copies can be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. The price of each report is given, and unless otherwise stated, the cost of postage on a report is 3d.

L/T307. **On the Theory of Dielectric Breakdown in Non-Ionic Crystals** by B. V. Paranjape. 9s.

On the assumption that Coulomb interaction between electrons is so strong that equilibrium amongst them is maintained more effectively through electron-electron interaction than through lattice-electron interaction, Fröhlich has extended his ideas on the theory of breakdown in amorphous substances to apply to pure ionic crystals. In this report his ideas are applied to pure non-ionic crystals.

L/T320. **The Effect of Dipoles on Electric Strength** by H. Pelzer. 7s. 6D.

It is shown that experimental findings about the intrinsic electric strength of high polymers could be explained by the influence of dipolar groups on electron scattering, if the dipoles were assumed to scatter independently. This assumption appears plausible even for crystalline substances.

Experimental evidence seems to indicate that the influence of order (crystalline or amorphous state) in the dielectric on intrinsic electric strength is not so important as had been believed. On the other hand, the increase of the low-temperature electric strength in the presence of dipoles appears to be of overriding importance.

N/T69. **Effect of Low Temperature on the Stability of Permanent Magnets of Alcomax III and other Alloys** by A. G. Clegg. 12s. 6D. (POSTAGE 4D.).

Measurements, using a magnetometer, have been made of the change in magnetization with temperature between $+60°C$ and $-60°C$ for magnets of Alcomax III, Columax, Alnico, and 35% and 15% cobalt steels with a range of dimension ratios. For Alcomax III and Columax, with working point below the $(BH)_{max}$ point, there is an irreversible decrease in the magnetization; elsewhere the magnetization increases with decreasing temperature. Irreversible decreases occur on the lower-coercivity materials with increasing temperatures. The irreversible changes, whether due to increase or decrease of temperature, can be eliminated through partial demagnetization by an alternating field. The results are correlated with the changes in the demagnetization curves of the materials with temperature.

Q/T128. **Improvement of Line Regulation by Series Capacitors** by S. Silbermann. 12s.

The use of capacitors, connected in parallel with an inductive load, for improving power factor is well known, but for improving regulation the use of capacitors, connected in series with overhead transmission lines, is less familiar.

The report gives methods of calculating the performance of series capacitors, and discusses the advantages and disadvantages of this method of improving regulation.

Q/T130. **Corrosion of Internal Tank Surfaces in Non-Conservator Transformers** by M. Waters. 10s. (POSTAGE 4D.).

Although tank corrosion is not a frequent occurrence it may cause considerable inconvenience to the users of transformers. The present report, which summarizes existing knowledge on this subject, is based upon replies to a questionnaire issued to members of the Association who are users or manufacturers of transformers.

Experience seems to indicate that where acidity is not due to excessive temperatures the cause must be sought in the presence of powerful catalysts in the oil, usually as part of the materials making up the transformer. Suspicion seems to rest mainly upon the varnishes which are used for impregnating the windings, particularly when they are not completely cured, or when all the solvent is not removed. The importance of using suitable varnishes is stressed.

Even when acidity has developed, corrosion may be retarded by taking certain simple precautions which appear to be widely used.

Q/T135. Some Practical Aspects of Series Capacitor Installations with Special Reference to Protection. A Critical Review of Published Information by J. A. Nicholson. 12s. 6D.

This review deals with the application of series capacitors to power-transmission systems. The factors governing the design and location of series-capacitor banks are briefly described and the protection of capacitors against overload due to fault conditions is reviewed in some detail. Overload protection is discussed with reference to applications to distribution systems and to large power systems where stability is of importance. Methods of protection alternative to those already published are discussed.

Q/T137. The Calculation of Flux, Losses and Forces in Iron-Cored Reactors with Distributed Air Gaps by M. Waters. 12s.

Methods are given for calculating the flux and losses of both tapped and untapped reactors.

Reasonable accuracy may be expected from flux calculations, but fringing and leakage fluxes are sufficiently large to make exact estimation of stray iron losses very difficult. It is suggested that empirical methods are the most practical way of dealing with such losses.

Electromagnetic forces are moderate in untapped reactors, and although there is a considerable radial leakage flux in tapped reactors the magnetomotive force is usually small, since these are often shunt reactors which cannot be subjected to short-circuit currents. Formulae for calculating the forces are given.

Q/T139. The Effects of Dissolved Gases in the Design and Operation of Oil Immersed Transformers by M. R. Dickson. 18s. (POSTAGE 4D.).

This reviews published information on the solution of gases in transformer oil, the effects of such gases on the properties of the oil, and other relevant material. The filling of transformers and the design of hermetically sealed transformers are discussed.

S/T62. Station Protection by a Length of Cable by R. Davis. 15s.

A length of cable connected between a terminal station and an overhead line behaves as a surge-protective device; surge voltages originating on the overhead system are modified in shape and amplitude by the cable. An attempt is made to assess quantitatively the performance of cable in reducing the frequency and severity of over-voltages produced by lightning discharges to the overhead system.

U/T133. Metal Transfer between Palladium and Silver Contacts at Low Inductances by J. Riddlestone. 12s. 6D. (POSTAGE 4D.).

The work described in reports U/T125 and U/T130 has been continued with palladium and silver contacts. This report gives results for transfer between contacts of these metals breaking a 6-volt circuit carrying currents between 3 amp and 15 amp with inductance in the range 0·07–96 μH.

Curves are given for the mean cathode gain and the growth of pip steepness for the two metals. The results are compared with those for platinum under similar conditions and it is inferred that transfer between metal contacts is generally the resultant of the superposition of four types of transfer, namely *residual transfer*, *reversed short-arc transfer*, *short-arc transfer*, and *long-arc transfer*.

Some theoretical explanation is given of the possible reasons for dissimilarity between the transfer for silver on the one hand and palladium and platinum on the other.

V/T116. Bridge for the Measurement of the Admittance of Electrical Insulation at Very-Low Frequencies by G. Mole and D. C. G. Smith. 12s. 6D. (POSTAGE 4D.).

The investigation described in E.R.A. report V/T105 has already demonstrated that dielectric dispersion (i.e. change of shunt capacitance with frequency) over the frequency range 0·1–50 c/s is a sensitive and direct measure of the moisture content of paper insulation.

A new form of bridge network has been developed in which the criterion of balance is that the voltages across two particular branches of the network are in quadrature. By this means it has been possible to construct a bridge which measures independently the shunt capacitance and shunt conductance of insulation with one side solidly earthed. The bridge is readily balanced and is direct-reading in capacitance and conductance. It is suitable for testing specimens of capacitance 10 $\mu\mu$F–1 μF over the frequency range 0·05–150 c/s and has a specimen lead 30 ft in length.

Z/T97. Self-Adjusting Welding Arcs: Drift in Power Source Output and Electrode Feed Rate by J. C. Needham. 12s. 6D. (POSTAGE 4D.).

The drift in the output of a d.c. motor generator, on load over a period of half an hour after first switching on, and initially set to give 250 amp at 25 volts, is determined for three load conditions, namely constant resistance, constant voltage, and constant current. Drift in the output characteristic is marked with the generator at high open-circuit voltage, but is greatly reduced at low open-circuit voltage owing to the reduced drift in excitation. Similar load tests with a transformer-rectifier set showed that the output is sensitive to mains fluctuations.

The effects of both power-source and electrode-feed-rate drift on arc equilibrium in self-adjusting arcs are discussed, and methods are suggested of overcoming them.

POST-WAR BUILDING STUDIES

Basic Design Temperatures for Space Heating

The 33rd report in the series 'Post-War Building Studies' has been published by the Stationery Office. It is entitled 'Basic Design Temperatures for Space Heating', and provides much-needed information on the external air temperature which should be assumed in the design of heating installations in this country.

An important consideration is the need to obviate uneconomic peak demands on gas and electricity supplies through the inadequacy of central-heating plants to cope with very cold weather. With, for example, a choice of 32° F as the minimum external basic design temperature, the overload margin of many plants is frequently insufficient to prevent discomfort during cold spells. On the other hand it is equally inefficient to provide so much heating capacity that it would not be fully used for most of the time. In the report, climatic data for various localities are given and the thermal characteristics of buildings are taken into account.

The report, which was prepared by a committee (on which The Institution was represented) under the chairmanship of Sir David Brunt, is priced at 3s. 6d.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH APRIL, 1956

	No. of Contributors	£	s.	d.
£1 000 and over	6	6000	0	0
£100 to <£1 000	29	6386	3	0
£5 to <£100	782	8522	16	5
£2 to <£5	1905	5255	17	2
Under £2	19453	10218	17	5
		£36383	14	0

APPOINTMENTS

COMMITTEE ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF SHIPS

On the nomination of the Cable Makers' Association, the Council have appointed Mr. F. W. Shaw to serve on the above Committee in place of Mr. W. W. Watkins.

On the nomination of the Institute of Marine Engineers, the Council have also appointed Mr. A. N. Savage, MEMBER, to serve on the Committee in place of Mr. N. H. Swancoat.

CORRESPONDENCE

In view of the heavy volume of correspondence received daily at the offices of The Institution it is of the greatest assistance when members, in replying to letters received from the Secretary, quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches the department concerned without delay but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

Members are reminded that notifications of changes of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one Local Centre or Sub-Centre to another arises as a result of a change of address, this transfer is automatically arranged by headquarters and the member concerned need not notify also the Hon. Secretary of the Local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested, when notifying a change of address, to give their full initials, their previous address and their class of membership.

WORLD POWER CONFERENCE

VIENNA: 17TH–23RD JUNE, 1956

A 'List of General Reports and Papers presented by January 10, 1956' has now been issued by the organizers of the Fifth World Power Conference to be held in Vienna this year (see March *Journal*, page 191). This booklet gives a list of reports on the eighteen Sections into which the papers fall. These reports, written by Austrian authors, comment on all the papers presented by the 10th January, 1956. The booklet also lists 260 individual papers submitted by 35 countries and three international organizations. It is available from the Secretary, British National Committee, World Power Conference, 201 Grand Buildings, Trafalgar Square, London, W.C.2.

Her Majesty's Government have appointed Sir Harold Hartley to represent them officially at the Fifth World Power Conference. Sir John Hacking will be official delegate representing the British National Committee, and the President of The Institution will be attending the Conference. The total number from the United Kingdom at the Conference is likely to be over 400.

ARRANGEMENTS WITH ENGINEERING INSTITUTIONS OVERSEA

Members who may have to travel abroad are reminded that in certain countries reciprocal arrangements are in operation for the extension of privileges to visiting members. The complete list of Institutions concerned is now as follows:

Country	*Institution*
Austria	Österreichischer Ingenieur- und Architekten-Verein.
Australia	Institution of Engineers, Australia.
Belgium	Société Royale Belge des Ingénieurs et des Industriels.
	Société Belge des Électriciens.
Brazil	Instituto de Engenharia, São Paulo.
Canada	Engineering Institute of Canada.
Denmark	Dansk Ingeniørforening.
Finland	Suomalaisten Teknikkojen Seura.
	Tekniska Föreningen i Finland.
France	Société des Ingénieurs Civils de France.
	Société Française des Électriciens.
Germany	Verein Deutscher Ingenieure.
	Verband Deutscher Elektrotechniker.
Holland	Koninklijk Instituut van Ingenieurs.
Iceland	Association of Chartered Engineers in Iceland.
India	Institution of Engineers, India.
Italy	Associazione Elettrotecnica Italiana.
Japan	Institute of Electrical Engineers of Japan.
New Zealand	New Zealand Institution of Engineers.
Norway	Norsk Elektroteknisk Forening.
	Norsk Ingeniørforening.
Rhodesia	Rhodesian Institution of Engineers.
South Africa	South African Institution of Civil Engineers.
	South African Institute of Electrical Engineers.
	South African Institution of Mechanical Engineers.
Sweden	Svenska Teknologföreningen.
Switzerland	Schweizerischer Ingenieur- und Architekten-Verein.
Turkey	Turkish Engineering Society.
United States	American Institute of Electrical Engineers.
	American Institute of Chemical Engineers.
	American Institute of Mining and Metallurgical Engineers.
	American Society of Civil Engineers.
	American Society of Mechanical Engineers.
	Institute of Radio Engineers.

The Secretary will gladly give letters of introduction to members visiting these countries.

CAMBRIDGE SUMMER SCHOOL IN AUTOMATIC COMPUTING, 1956

A Summer School in programme design for automatic digital computing machines will be held in the University Mathematical Laboratory at Cambridge from the 17th to 28th September, 1956. It will be along the same lines as those held previously, and will give a basic training in the mathematical use of machines, dealing with the processes employed and their embodiment in programmes which specify detailed operation. Lectures and practical classes will be held in the design of programmes for the EDSAC, the machine which has been built in the Laboratory.

A detailed syllabus and form of application for admission may be obtained from Mr. G. F. Hickson, Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge, to whom the completed application form should be returned not later than the 15th June, 1956.

METALLURGICAL CONGRESS

CHICAGO: 2ND–8TH NOVEMBER, 1957

The 2nd World Metallurgical Congress, which is organized by the American Society for Metals, will be held in Chicago from the 2nd to 8th November, 1957. Those attending the Congress may, if they so desire, take part in a conducted tour of important plants and institutions, setting out from New York on the 19th October and arriving in Chicago for the opening of the Congress on the 2nd November. Members may choose one of nine separate tours, each of which covers a special range of interests. Running concurrently, and in conjunction with the Congress, will be the 39th annual National Metal Congress and National Metal Exposition, also sponsored by the American Society for Metals, and the 2nd World Congress on Nondestructive Testing, sponsored by the Society for Nondestructive Testing.

At the 1st World Metallurgical Congress held in Detroit in 1951, 510 people from 39 oversea nations participated in the tours, meetings and discussions.

Further details may be obtained from the Secretary, American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio, U.S.A.

POZNAN INTERNATIONAL FAIR

17TH JUNE–1ST JULY, 1956

The 25th International Fair at Poznan, Poland, will be held from the 17th June to 1st July, 1956. Members who are interested in visiting this Fair (at the expense of the Polish authorities) may obtain further details from the Head of the Polish Purchasing Mission in the United Kingdom, 15 Devonshire Street, London, W.1.

INSTITUTION OF ENGINEERS, INDIA

Notice has been received that the *Journal of The Institution of Engineers, India*, is now published monthly. There has also been a change in the annual subscription, which is now £2 14s.

CITY AND GUILDS BROADSHEETS

The vital work undertaken by the City and Guilds of London Institute in the field of technical education and training increases rapidly year by year. That the Institute are concerned to keep a proper flow of information about these activities to all interested people is clearly shown by the initiation of a series of City and Guilds Broadsheets. These will give brief descriptions of current activities and will surely be welcomed by all those in the educational field and in industry who are connected with the work of the Institute. The first number, published in February 1956, includes notes on the new Courses for Electrical Technicians, the Insignia Award in Technology and a brief progress report on the work of the Associated Examining Board, which first conducted examinations for the General Certificate of Education in 1955. It is proposed to issue the Broadsheet four times a year.

APPLIED ELECTRICAL RESEARCH

The Regional Advisory Council for Higher Technological Education in London and the Home Counties has for the eighth successive year prepared a summary of applied research in electrical engineering which is in progress in universities and technical colleges in the Region. These include Imperial College, King's College, Queen Mary College and University College, London University; Battersea, Borough, Northampton, Regent Street and Woolwich Polytechnics; and Norwood, Enfield, South East London, South East Essex and South West Essex Technical Colleges. A long list of subjects of research is given. The following few subjects have been picked out as examples: colour-television tube development; super-regenerative transistor receivers; the magnetic and dielectric properties of ferrites at radio frequencies; a study of the two-phase motor as an integrator of current products; an investigation into the origins of transformer noise; dielectric amplifiers; electro-machining; transistor noise; design of a high-power magnetron; and animal resistance to electric shock.

In issuing this document the Regional Advisory Council hope to stimulate applied research and to help in establishing contacts between industrial firms and the colleges concerned. Copies of the summary are available from the Secretary, Regional Advisory Council for Higher Technological Education in London and the Home Counties, Tavistock House South, Tavistock Square, London, W.C.1.

THE OVER-SEAS LEAGUE

The Secretary has been asked to draw members' attention to the service which the Over-Seas [*sic*] League provides to British subjects or Commonwealth citizens both at home and abroad. The principal aims of the League are:

(*a*) To promote friendship and understanding amongst British subjects and Commonwealth citizens all over the world.

(*b*) To encourage individual service to the British Commonwealth and Empire.

(*c*) To resist movements and influences which are directed against its unity and well being.

Besides furthering these aims by individual contacts, social activities, travelling scholarships, visits, the magazine *Overseas*, etc., the League has a well-equipped club-house in the West End of London, where bedrooms and meals are available. Other club-houses are situated in large towns in the United Kingdom and in Australia. The entrance fee and the subscription to the League are very modest since the League has a large membership, being in general open to anyone from Great Britain or the Commonwealth.

Any member of The Institution who is interested is invited to write to the Secretary at Over-Seas House, St. James's, S.W.1, from whom particulars of the League can be obtained.

CAMBRIDGE UNIVERSITY ENGINEERS ASSOCIATION

The Cambridge University Engineers Association, which was founded in 1929, aims at keeping former students of the University Engineering Department in touch with one another and with the research in progress and other current activities of the Department. The present membership of the Association is approximately 2000 and a new Register of Members is now being printed. The customary Bulletin of the Association is due for publication this month.

The Executive Committee of the Association is anxious to increase its membership by trying to regain contact with the many Cambridge graduates with whom it has been lost. Life membership is secured by a single payment of two guineas, and full particulars of the Association, with a form of application for membership, are obtainable from the Hon. Secretary, C.U.E.A., Engineering Laboratory, Trumpington Street, Cambridge.

The Executive Committee wish to give advance notice of the next summer reunion, to be held in Cambridge on the 14th July, 1956. There will be an at-home in the Engineering Laboratories during the afternoon, the Annual General Meeting of the Association will be held at 5 p.m. and the Association's dinner will take place in the hall of St. John's College at 8.15 p.m. Ladies accompanying members will be welcome at the at-home and at the dinner.

EDITORIAL VACANCY ON THE INSTITUTION STAFF

Applications are invited for the post of Editorial Assistant for the *Proceedings* of The Institution. The qualifications required are an engineering or science degree and some engineering experience, with the ability to sub-edit high-class technical copy. Applicants should preferably be between the ages of 25–30 (approximately). This is a progressive post, the commencing salary depending on age and experience. Entry to the superannuation scheme would follow a short period of service. Those who are interested should write to the Secretary, The Institution of Electrical Engineers, Savoy Place, W.C.2, giving full particulars of their education, training and experience.

SCIENTIFIC EDUCATION IN SCHOOLS

A PROGRESS REPORT FROM THE NEW INDUSTRIAL FUND

The Industrial Fund for the Advancement of Scientific Education in Schools was formed in the autumn of last year. Its purpose is to help the teaching of science in Independent (i.e. Public) and Direct Grant schools by capital grants for the building and modernizing of science laboratories. When the formation of the Fund was announced it was stated that 17 founder members were providing £1 500 000. Since then some 75 additional companies have agreed to support the Fund, whose assets now total about £3 000 000. The list of contributing companies includes many (but not all) of the large electrical firms.

No less than 439 schools have applied for assistance from the Fund. These include 179 Independent boys schools, 115 Independent girls schools and 75 Direct Grant boys schools. Of the 176 Independent and Direct Grant schools represented on the Headmasters' Conference all except six have or will be applying for grants. From information supplied by the schools it is known that the average number of boys in mathematical and science sixth forms is now 50% of the total number in all sixth forms. It is interesting that in 1935 the corresponding figure was 45%, so that in the Independent and Direct Grant schools there has been a swing of only 5% towards a scientific education. On the other hand the number of boys over the age of 13 has increased by over one-third since before the war, and with larger sixth forms there are now over twice as many boys in the mathematical and science sixth forms as there were in 1935. It is noteworthy that in the two types of school for which the Fund has been formed the urgent teaching problem is lack of capital for science laboratories and not shortage of science teachers.

The Committee administering the Fund have appointed four assessors to act as technical advisers both to the Committee and to the schools. They have also published a brochure setting out good architectural practice for the building and equipping of school science laboratories. By the 1st May, about 45 schools had been visited by an assessor; 7 offers had been made by the Committee and 20 were under negotiation.

The Committee have recently estimated that the purposes of the Fund can be adequately carried out if a further £600 000 is forthcoming from industry. So far only certain companies have been approached but a more general appeal will be made shortly.

RADIO WAVE PROPAGATION

AN INTERNATIONAL SYMPOSIUM IN PARIS: SEPTEMBER, 1956

An international symposium on 'Current Problems in the Propagation of Radio Waves', which is being organized by the Comité National Français de Radioélectricité Scientifique and the Société des Radioélectriciens, will be held in Paris from the 17th to 22nd September, 1956. The proposed subjects to be considered fall under the following four headings:

(*a*) Propagation of ultra-short waves far beyond the horizon.

(*b*) Influence of the sun on the radiation and propagation of waves.

(*c*) Ionospheric propagation.

(*d*) Miscellaneous questions—in particular, propagation of waves of frequency less than 20 kc/s.

All those interested in attending the symposium should apply immediately to the Société des Radioélectriciens, Colloque Propagation, 14 avenue Pierre-Larousse, Malakoff (Seine), France.

BRITISH COMMONWEALTH WELDING CONFERENCE

17TH–29TH JUNE, 1957

The Institute of Welding is organizing a Conference which has among its aims the exchange of technical information about welding processes and their applications within the Commonwealth, and the emphasizing of the importance of welding to modern engineering production. It will be held in London and Saltburn-by-Sea, Yorkshire, from the 17th to 29th June, 1957. The Conference begins and ends in London, and includes a period at Saltburn from the 23rd to 27th June. The programme comprises technical discussion of papers, works visits (from Saltburn) and a full social programme including a banquet and special excursions for ladies accompanying participants. The proceedings of the Conference will be published in 1958. Offers to contribute papers should reach the Secretary of the Conference by the 1st August, 1956. Those interested should apply for particulars to The Secretary (C.W.C.), The Institute of Welding, 2 Buckingham Palace Gardens, London, S.W.1.

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Queensland

Chairman: A. S. FAULKNER.

Hon. Secretary: W. I. GEORGE, B.E., c/o The English Electric Co. Ltd., P.O. Box 11 Annerley, Brisbane.

South Australia

Chairman: K. H. MILNE, B.E.

Hon. Secretary: J. W. CROMPTON, B.E., 139 Fisher Street, Malvern.

Victoria and Tasmania

Chairman: Appointment pending.

Hon. Secretary: C. A. P. OLDFIELD, c/o State Electricity Commission of Victoria, 22–32 William Street, Melbourne.

Western Australia

Chairman: K. W. TAPLIN, B.E.

Hon. Secretary and Treasurer: R. R. LAKE, B.E., c/o 132 Murray Street, Perth.

INDIA

Bombay

Chairman: P. L. VERMA, B.SC.

Hon. Secretary: T. M. SHIVRAM, Services Engineer (North), B.E.S. & T. Undertaking, Electric House, Post Fort, Bombay, I.

Madras

Chairman: Appointment pending.

Hon. Secretary: R. WRIGHT, M.B.E., 6 Carnatic Gardens, Madras, 12.

MALAYA AND SINGAPORE

Chairman: THE OVERSEA REPRESENTATIVE OF THE COUNCIL.

NEW ZEALAND

Chairman: F. T. KISSEL, I.S.O., B.SC.

Hon. Secretary: E. H. R. GREEN, C.B.E., M.SC., Chief Engineer, G.P.O. Wellington, C.1.

SOUTH AFRICA

Transvaal

Chairman and Hon. Secretary: A. W. LINEKER, B.SC., P.O. Box 7794, Johannesburg.

Oversea Representatives of the Council

ARGENTINA

A. C. TOWERS, Acassuso 841, Olivos, F.N.G.B.M., Prov. de Buenos Aires.

BRAZIL

C. H. DE NORDWALL, Caixa Postal 3164, Rio de Janeiro.

Oversea Representatives of the Council (*contd.*)

BURMA

C. H. MELLOR, c/o Rangoon Electric Supply Board, 503/9 Merchant Street, Rangoon.

CANADA

J. M. THOMSON, M.A.SC., PH.D., Ferranti Electric Ltd., Mount Dennis, Toronto 15, Ontario.

CAPE PROVINCE

C. G. DOWNIE, B.SC., c/o City Electricity Dept., P.O. Box 82, Cape Town.

CEYLON

D. P. BENNETT, c/o Walker, Sons and Co. Ltd., Colombo.

EAST AFRICA

A. O. COSGROVE, B.SC., The General Electric Co. Ltd., P.O. Box 5100, Nairobi.

FAR EAST

D. S. HILL, Reiss, Bradley and Co. Ltd., National City Bank of New York Building, 2 Queens Road C, Hong Kong.

FRANCE

P. M. J. AILLERET, Électricité de France, 12 Place des États-Unis, Paris (16e).

Deputy Representative: M. E. LABORDE, ING.E.S.E., L.ÉS.SC., Électricité de France, 12 Place des États-Unis, Paris (16e).

INDIA

F. WADE-COOPER, Magnet House, Chittaranjan Avenue, P.O. Box 8974, Calcutta, 13.

Deputy Representative: L. W. BRAZEL, c/o Calcutta Electric Supply Corporation, Calcutta.

ISRAEL

B. F. MOSS, 94 Hayarkon Street, Tel-Aviv.

MALAYA AND SINGAPORE

J. SHARPLES, B.SC.(ENG.), Central Electricity Board, Head Office, Batu Road, P.O. Box 1003, Kuala Lumpur, Malaya.

MIDDLE EAST

J. M. MORRIS, O.B.E., The Port Directorate, Basrah, Iraq.

NATAL

R. M. O. SIMPSON, c/o Electricity Dept., P.O. Box 147, Durban.

NEAR EAST

A. G. COATES, c/o Iraq Petroleum Co. Ltd., P.O. Box 51, Homs, Syria.

Deputy Representative: PROFESSOR R. W. SLOANE, M.A., PH.D., B.SC., Director of Engineering, Experimental and Service Laboratories, American University of Beirut, Division of Engineering, Beirut, Lebanon.

NEW SOUTH WALES

V. J. F. BRAIN, B.E., Chairman, The Electricity Authority of New South Wales, Treasury Building, Bridge Street, Sydney.

NEW ZEALAND

E. H. R. GREEN, C.B.E., M.SC., Chief Engineer, General Post Office, Wellington, C.1.

PAKISTAN

R. W. BAILEY, B.SC.(ENG.), c/o Greaves Crompton Parkinson, Ltd., Saifee Development Chambers, P.O. Box 194, Bunder Road, Karachi.

QUEENSLAND

J. S. JUST, c/o Box 1067N, G.P.O., Brisbane.

RHODESIA

A. B. COWEN, O.B.E., P.O. Box 377, Salisbury.

SOUTH AUSTRALIA

G. H. MACHIN, B.E., c/o The Electricity Trust of South Australia, Box 412c, G.P.O., Adelaide.

SWITZERLAND

L. W. HAYES, O.B.E., 43 Quai Wilson, Geneva.

TRANSVAAL

A. W. LINEKER, B.SC., P.O. Box 7794, Johannesburg.

UNITED STATES OF AMERICA

Hon. Secretary: R. H. BARCLAY, The J. G. White Engineering Corporation, 80 Broad Street, New York 4, N.Y., U.S.A.

VICTORIA AND TASMANIA

PROFESSOR C. E. MOORHOUSE, M.E.E., Department of Electrical Engineering, University of Melbourne, Carlton, N.3, Victoria.

WEST AFRICA

J. HOUSTON ANGUS, Electricity Corporation of Nigeria, Ijaros, Lagos, Nigeria.

WEST INDIES

H. D. WALDEN, B.SC., c/o Trinidad Leaseholds, Ltd. 19 La Carriere Road, Point-a-Pierre, Trinidad.

WESTERN AUSTRALIA

F. C. EDMONSON, c/o Electricity and Gas Dept., 132 Murray Street, Perth.

Joint Oversea Groups

ARGENTINA
Chairman: R. M. DRYSDALE, A.M.I.MECH.E.
Hon. Secretary and Treasurer: J. COOMBES, A.M.I.C.E., c/o Percy Grant & Co., Reconquista 314, Buenos Aires, Argentina.

HONG KONG
Chairman: S. E. FABER.
Hon. Secretary and Treasurer: J. J. ROBSON, A.M.I.C.E., c/o Port Works Office, Public Works Dept., Hong Kong.

IRAQ AND PERSIAN GULF
Chairman: N. D. FETTO, B.SC.(ENG.), M.I.C.E.
Hon. Secretary: J. A. C. KING, A.M.I.E.E., c/o Department of Electricity, Government of Kuwait, Kuwait, Persian Gulf.

SINGAPORE/MALAYAN
Chairman: R. J. HOLLIS-BEE, A.C.G.I., M.I.C.E.
Hon. Secretary: C. G. V. RUDD, M.SC., A.M.I.MECH.E., A.M.I.E.E., Alliance Engineering Co. Ltd., 6/7 Telegraph Street, Singapore.

WEST AFRICA
Chairman: J. HOUSTON ANGUS, M.I.MECH.E., M.I.E.E.
Hon. Secretary: R. E. J. WHITE, A.M.I.MECH.E., A.F.R.Ae.S., c/o U.A.C. (Tech.) Ltd., P.O. Box 570, Lagos, Nigeria.

Graduate and Student Section Officers

BRISTOL
Chairman: S. L. HURST, B.SC.(ENG.).
Hon. Secretary: G. D. MILLER, Equipment Engineering Dept., Westinghouse Brake & Signal Co. Ltd., New Road, Chippenham, Wilts.

CARDIFF
Chairman: F. BLEACH, B.SC.(ENG.).
Vice-Chairman and Hon. Secretary: J. H. DENMAN, 66 Park Fields Road, Bridgend, Glam.

EAST MIDLAND
Chairman: P. J. BHATT, B.SC.(ENG.).
Hon. Secretary: G. M. BAYLEY, B.SC.(ENG.), c/o Brush Electrical Engineering Co. Machine Design Dept., Loughborough.

LONDON
Chairman: M. H. F. COLLINS.
Hon. Secretary: E. L. JONES, B.SC., 9 Dorchester Avenue, Hoddesdon, Herts.

MERSEY AND NORTH WALES
Chairman: S. G. GRIFFITHS.
Hon. Secretary: J. C. B. MACKEAND, B.SC., School Cottage, Knowsley Lane, Prescot, Lancs.

Graduate and Student Section Officers (*contd.*)

NORTH-EASTERN
Chairman: N. YOUNG.
Hon. Secretary and Treasurer: J. N. H. WARD, B.SC., 72 Osborne Road, Jesmond, Newcastle on Tyne.

NORTH MIDLAND
Chairman: H. J. TOWSE, B.SC.(ENG.).
Hon. Secretary: D. PITTS, 55 Broad Lane, Bradford, 4.

NORTH SCOTLAND
Chairman: J. B. ABBOTT.
Hon. Secretary: A. J. S. DAVIDSON, B.SC., c/o Electrical Engineering Dept., Queens College, Dundee.

NORTH STAFFORDSHIRE
Chairman: D. K. ARKWRIGHT, B.SC.(ENG.).
Hon. Secretary: W. G. LLOYD, 206 Doxey, Stafford.

NORTH-WESTERN
Chairman: D. MANGNALL.
Hon. Secretary: J. C. HOPKINS, B.SC., Research Dept., Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.

NORTHERN IRELAND
Chairman: W. M. BARRON.
Hon. Secretary: T. C. JACKSON, 99 Deerpark Road, Belfast.

RUGBY
Chairman: A. R. PETHERAM, B.SC.(ENG.).
Hon. Secretary: A. J. GILBERT, Plant Engineering Department, British Thomson-Houston Co. Ltd., Rugby.

SHEFFIELD
Chairman: J. R. BENNETT.
Hon. Secretary: J. BENNETT, 7 Dale Road, Rotherham.

SOUTH-EAST SCOTLAND
Chairman: J. BEWS.
Hon. Secretary and Treasurer: M. B. MCNEIL, 13 Stirling Road, Trinity, Edinburgh, 5.

SOUTH MIDLAND
Chairman: J. F. WINTERBOTTOM, B.SC.
Hon. Secretary: A. H. BOYSON, 106 Somerset Road, Edgbaston, Birmingham, 15.

Chairman: A. AKED, B.SC.
Hon. Secretary: J. C. EASTON, 29 Castle-Chimmins Road, Cambuslang, Glasgow.

SOUTHERN
Chairman: A. TEAGUE.
Hon. Secretary: H. G. NEW, 67 Fortunes Way, Bedhampton, Hants.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 2nd April, 1956.

ELECTIONS

Members

ANDREWES, Admiral Sir William Gerrard, K.B.E., C.B., D.S.O.
DANA, Alan Standish, S.B.

Associate Members

BRAYE, James Philip Wauchope, M.A.
BULL, René.
CRANE, Peter Henry Gordon, M.SC.
DAIN, John Hill.
FARUQUI, Abdus Samad, B.SC., B.ENG.
FOWLE, Cyril John Digby, B.SC.
HOLIDAY, Arthur.
JAMES, Edward Ernest.
KIRBY, Thomas.
MURRAY, Neil Grant.
SLAVIN, Peter Edmund, B.SC.(ENG.).
STIRLING, Andrew Gibson, B.SC.
SUTTON, Kenneth Howard.
WAIT, Robert William.
WHITE, Alfred Scott.
WHITFIELD, George Alan, B.SC.
WOODWARK, Richard Graham, D.S.C., M.A.

Associates

COOPER, Oliver Grosvenor.
FOX, Percival Osmund.
MACDONALD, Douglas Hamilton.
NEALE, Geoffrey Baker.
TOMPKINSON, Edwin Vincent.

TRANSFERS

Associate Member to Member

BAKER, Cecil Graham.
BARNARD, George Philip, D.SC., PH.D.
BIND, Reginald Maurice, B.SC.(ENG.).
BROWN, Eric Frank.
CANNING, Sidney, B.SC.(ENG.).
CLARK, Joseph Kenneth, B.ENG.
COLBORN, Cecil Herbert, B.SC.
COTSWORTH, Walter Manning.
FRANCIS, Albert Victor.
GALLOWAY, Donald Frederick, PH.D., B.SC.
GINGER, Lionel Alan McLean.
HOLMES, Frank, B.SC.
LINDSEY, Arthur James, M.SC., PH.D.
MCKERROW, Igor, B.SC.(ENG.).
MADDEN, Terence Arthur George, B.SC.TECH.
PHILLIPS, Frederick Philip, B.SC.(ENG.).
PHILLIPS, Stanley Arthur, B.SC.(ENG.).
PORTER, John Ernest.
SYKE, George, DIPL.ING.
TIZARD, Richard Henry, B.A.
WOLSTENHOLME, Arthur Scott.

Associate to Associate Member

SINGH, Gurbachan.

Graduate to Associate Member

ABBOTT, Frank Anthony Bokenham.
ACKERMANN, Dirk Wouter, B.SC.(ENG.).
ARNAUD, Frederick Cooper, B.SC.(ENG.).
ATKINSON, Albert Noel.
ATKINSON, Thomas.
BAINES, Alfred Humphrey Peter.
BARBER, Arthur Richard.
BARTON, Robert Frederick, B.A.

Graduate to Associate Member (contd.)

BATES, Roy John Russell.
BECKER, Carl Sidney McCartney.
BETHELL, Jeffrey Gordon.
BILLINGTON, Kenneth William.
BRADSHAW, Sqdn.-Ldr. Ronald Stanley, B.SC.(ENG.), B.A.F.
BRAY, Donald Harry Arthur.
BROCKMAN, Maurice John, B.SC. (ENG.).
BROTHERS, Donald Charles, B.SC. (ENG.).
BUCHANAN, James Macalister, B.SC.(ENG.).
BUNDELL, John Howard, B.E.
BURKE, James Neil.
BURNITT, John Edwin.
CARRINGTON, James Edward.
CARRUTHERS, Peter Osborne, B.E.
CHOUDHURY, Jyotsna Kumar, M.SC.TECH.
COATS, John McArthur, B.SC.(ENG.).
COGHLAN, John Ellery, B.E.
DAVIES, Thomas William, M.SC.
DICKENS, Dennis Albert.
DIXON, Kenneth Norman, B.SC.
EVERSFIELD, Frederick Furneaux.
FORD, Arthur William, B.SC.(ENG.).
FORRESTER, Jack Thorpe.
GARMAN, Arthur Abraham, B.SC. TECH.
GEORGE, Donald.
GODDARD, George Horace.
GOPALAN, Balasubramanya, B.SC.
GRANT, John Vass, B.SC.
GREEN, Philip Richard.
GREEN, Richard Anthony Woodsworth, B.SC.(ENG.).
GREENWAY, Ronald.
HALL, Alexander McConnell, PH.D., B.SC.
HAWKES, Henry William, B.SC.
HENDRIKS, Joseph Lawrence.
HORTON, Harry France.
HOSKIN, Richard David.
HUGHES, David Crowther, B.E.
IBBOTSON, Frank John, B.SC.
IBBOTSON, John Walter.
JOHNSON, Edward William.
KENDALL, Philip George, B.SC.(ENG.).
KURZEWSKI, Charles George, B.SC. (ENG.).
LANGHORNE, Thomas Blacklock, B.SC.(ENG.).
LAWSON, William.
LINGARD, George Tyler.
LOGAN, John Frederick, B.E.
MACLEOD, Malcolm Keith, B.SC.
MANWARING, David Brudenell, B.SC.
MARRIOTT, Francis George.
MARSHALL, Eric.
MAYO, Dennis Stewart.
MEREDITH, Ronald Mervyn William.
MOORE, David, B.SC.
MUIRHEAD, John.
NARAYAN, Nilakantier Sankar, B.SC.
PEACH, Stanley George.
PINK, Joseph Albert.
PLATT, Victor.
PONIEWIERSKI, Jerzy.
POOLE, John Carttar.
PRESTT, Edward, B.SC.TECH.
ROWLANDS, Vernon.
SIMMONS, David John, B.SC.(ENG.).
SMITH, Thomas Eric Claude.
SOUTHBY, Arthur Cyril.
SPENCE, John Barber, B.SC.(ENG.).
STONE, Allan Bertram.
STRAUSS, Walter, B.E.
STUART, Gordon, B.SC.(ENG.).
TAYLOR, Edward.
THOMAS, John Charles.
TOWNSEND, John Charles, B.SC. (ENG.).
UREN, John.
WALKER, Alan.
WATSON, Derek, B.SC.(ENG.).
WHILLOCK, Richard George.
WHITE, James Edward Bernall, B.SC.(ENG.).
WILLIAMS, Arnold.
WILLIAMS, Arthur Parry.
WILSON, John Robert.
WINCOTT, Leslie Moreland.
WISE, Charles Frederick.
WRIGLEY, Edmund Cecil Warren.
YOUNG, George.

Student to Associate Member

ALLEN, Murray William, B.E.
DAVIES, Edward Hodges, B.SC.(ENG.).
GAMBIER, Dennis Morley.
HEARN, Michael.
MOTTERSHEAD, George Albert.
QUARTERMAINE, Ronald Alfred Edward.
TRIGWELL, Kenneth Moppett.

The following elections and transfers approved by the Council are effective from the 5th April, 1956.

ELECTIONS

Graduates

AKHTAR, Javid, B.A.
ANELLI, Frederick David, B.SC.
BARLOW, Gerald Patrick, B.SC.
BARWELL, William Arthur.
BASON, Charles Martin.
BAYLIS, Geoffrey Noel, B.SC.
BEAURAIN, Roger.
BOLAM, David Kirkley.
CHAMBERS, John Frederick.
CHAN, Yee Kwan.
CHANDLER, John Arthur, B.SC. (ENG.).
COLE, Frederick Charles.
COLLIE, William Milne.
CORNICK, Keith Joseph.
COXALL, David Jerome.
CRAWSHAW, William.
CROUCHER, Douglas.
DAVIS, Ronald Joseph.
DUDMAN, Edward Charles.
ENEVER, Richard John, B.A.
EVANS, Leonard.
FAULKNER, Kenneth William.
FLEMING, Albert Thomas.
GAITELY, Lionel Frederick, B.SC (ENG.).
GHOSE, Tarun Kumar, B.SC.
GOOCH, Albert William Terrence, B.A.
HAAGENSEN, Hans Frederick.
HARDING, Arthur Phillip.
HARRIS, Edmund Arthur.
HARRIS, John Granger.
HATTON, Michael Roger.
HIGSON, Albert.
HILTON, Kenneth George, B.A.
HINDS, Frederick William.
HODGKISS, Harry.
HOWE, Michael David, B.SC.
HUNT, John Joseph, B.SC.
HUNTER, Neil Christopher.
HURR, Ernest Roy.
HYDE, Hubert Barrie.
JACKSON, Gordon Lindsay.
JEFFREY, James Robert William.
JERAMS, Eric Stanley.
KEEN, Geoffrey Hugh David.
KENNEDY, William.
KEOGH, Patrick Leslie.
KIRK, Joseph.
KRAMER, Johannes Joachim.
LAMBARD, Bernard Ralph.
LANGSTON, Philip Anthony, B.SC. (ENG.).
LEE, Arthur William.
LIVESEY, Eric.
LONGBOTTOM, John.
MacKELLAR, John Campbell.
MAMAK, Raghbir Singh, B.SC.
MATYSZCZYK, Czeslaw.
MORGAN, Peter John.
MUSTAPHA, Muhammadu Dodo.
NELSON, Wilfrid Bernard.
NOAKS, David Richard, B.SC.(ENG.).
PAYNE, Kenneth Gordon.
PEARSON, Phares.
POTTER, Leonard.
POTTS, Thomas Henry.
RANSOM, Edward Dudley, B.E.
RANSON, Arthur Terence.
REDMAN, Alan.
REUSS, Konstantin Michael, B.SC. (ENG.).
RIGNALL, Michael William.
ROEBUCK, Arthur.
SANYAL, Ardhendu Sekhar.
SIMONS, Harry Keith, B.SC.
SIMONS, Richard James.
SINGH, C. I. O. Uttam Kartar, LL.B.
STANLEY, Eric John.
TERRY, James Metcalfe.
WALIGO, Abraham Pellew Nkalubo.
WALKER, Charles Willis.
WEBSTER, Arthur.
WHEATLEY, Dennis Edward.
WILLIAMSON, Keith Harold.
WILTCHER, Bernard Frederick.
WONG, Kee Koon.
WRIGHT, John.
WYATT, Walter William Dennis.

Students

ABBOTT, John Michael.
ADDISON, Geoffrey.
ANGELIS, Nicholas.
AZIZ, Faik Mohammed Abdul.
BALL, Ian Desborough.
BARKER, Maurice.
BARRON, Donald Robert.
BARRON, Martin Sean.
BEADLE, John Alan.
BEALE, Peter Henry.
BECKETT, James Gilbert.
BELL, William David.
BERRY, John William.
BERRY, Krishan Kumar.
BICKERTON, William.
BLACK, Sydney Thomas Marshall.
BLACKBURN, Alan John.
BLAKE, David John, B.SC.
BOLTON, Francis.
BOOTE, Gordon.
BRADBURY, Ralph Anthony.
BRANFORD, Ronald.
BRISTER, Raymond George.
BROWN, Anthony George Farthing.
BURDEN, Barry Thurlow.
BURDEN, John Peter, B.SC.
BURROWS, Michael Leonard.
CADDY, Roy.
CADMAN, Harry.
CALLICK, Alan David.
CALVERT, Patrick Philip Allen.
CAMPBELL, John George Govan.
CHAMBERLAIN, Edwin Arthur.
CHAPPLE, Keith.
CHISHOLM, Thomas.
CHRISTOPOULOS, Andre.
COLDBECK, John Stanley.
COLE, George.
COLWELL, Brian.
CONNORS, Frank Thomas.
COOK, Joseph Gordon, B.SC.
CORBISHLEY, Alan George.
COWAN, Derek Ashley.
CUMBERS, Michael Brodie.
DANIELS, John Michael.
DAVIES, Gwynfor.
DAVIES, John James Littler.
DAYSON, Ronald Cyril.
DELAMERE, William Alan.
DELL, Frederick Reginald Edward.
DERBY, Fergus.
DICKINSON, William Ian.
DIXCEE, Angus.
DONOVAN, Roy Patrick.
DRYBURGH, Eric Campbell.
DYSON, Arthur Frank.
EATON, Edward Harry.
ECCLES, David Alan.
EVANS, Terence William.
FARRIER, Norman Langford.
FAWCETT, Dennis, B.SC.
FINN, Gordon George David.
FORD, Brian John.
FOSTER, David Martyn.
FULFORD, Barry Lewis.
FULLER, Brian Walter.
GANN, Michael John.
GERMAN, James Colin.
GHOSHAL, Brindabon Behari.
GIBSON, Alfred.
GILL, Allan.
GLACKEN, Patrick.
GOLDSTEIN, Samuel.
GREEN, Peter Alec.
GREENAWAY, Hugh Thomas.
GRICE, Edmund.
GRIFFITHS, David Alwyn, B.SC.
GRIMA, John.
GRUNSTEIN, Moise Levy.
GUSWELL, Derek Bryan.
HANFORD, Paul Humphrey.
HARGREAVES, Peter.
HARLEY, George Frederick.
HARPER, Robert Stanley Mack.
HARTGILL, John Clavering.
HARTLEY, Derek.
HASHIM, Fuad Raouf.
HASHIM, Mohammed Hussain Raouf.
HEDDERLY, David Leslie.
HEPWORTH, John Charles Harold.
HICKS, Edward Reginald.
HOPE, Jack, B.SC.(ENG.).
HORTON, Desmond.
HOUSTON, David Andrew.
HOWARD, John Howard.
HUMPHREYS, James Patrick.
HUNTLEY, Michael William Elliott.
IBALL, Eric Kingsley.
IVESON, Albert John.
JONES, Clive Lynn.
KAKATI, Robindra Nath.
KEEN, Peter Edward Roland.
KEYS, Thomas James.
KING, Brian.
KIRKWOOD, David Malcolm.
KUMAR, Gurbaksh Rai, B.E.
KUMAR, Gyanendra, B.SC.
LATIF, Shaikh Abdul, B.E.
LEWIS, William David.
LIEW, G. Hoe.
LING, Dennis Arthur, B.SC.(ENG.).
LUSH, David Michael.
MACFARLANE, Derek Hanson.
McKENNA, Turlough Donn.
McSHANE, Robert Rowland.
MAGUIRE, James.
MAIDENS, Michael Joseph.
MALCOLM, James Duncan.
MARSHALL, Peter Brian.
MASSIS, Zainudeen Mohammed.
MATTHEWS, Thomas Graham.
MILLS, David.
MOSS, William Joseph Francis.
MUNNS, John Ronald.
MURPHY, John Eric, B.SC.
MURPHY, Joseph William.
NEWMAN, Peter Leslie.
NICHOLLS, Malcolm Robert, M.SC.
NJOKU, Augustine Obgonna.
NORRIE, William Malcolm, B.SC.
NORRIS, Ian Stuart, B.SC.
ONYEJESI, Gabriel Rapheal Onwujiobi.

Students (contd.)

ORR, Brian Hugh.
OSBORNE, Colin Sidney.
PAPADATOS, John.
PARKER, Timothy John Kingston.
PARRATT, Alan Lawrence.
PARSONS, David Ernest William.
PATEL, Harshadrai Jivabhai, B.E.
PAYNE, David John.
PEARCE, John Arnold.
PIETRUSZKO, Witold.
PREECE, Francis John William.
PRICE, Colin Stewart.
PRICE, Philip Ernest.
QUINNEN, Ronald.
RAI, Sec.-Lt. Ram Narain, B.SC., R.M.E.
RAMANATHAN, Vaidyanath, B.E.
RAO, Boddapath Chidambara.
RASTOGI, Suresh Chandra.
RAY, Colin George David.
READER, Dennis Michael.
RIMMER, Kenneth Frank, B.SC.
RITCHEY, Alan.
ROACH, Glynne.
ROBERTS, Wilfred.
ROBINSON, Geoffrey Vincent.
ROULSTON, David John.
ROUTIER, John Sinel.
RUNDLETT, David Joseph.
SAKSENA, Shrawan Kumar.
SALAM, Hassan Paddy Abdel.
SAMANTA, Benoy Kumar.
SAMUEL, Emrys Morgan.
SENIOR, Graham.
SHAH, Dhirajlal Bechardas, B.E.
SHAPLEY, Arnold Keith.
SLAPP, John.
SMITH, David Alfred.
SMITH, Frank David.
SMITH, Ralph Graham.
SMITH, Roy Barrington.
SMITH, Victor.
SMITH, Walter Ernest.
SMYTH, Patrick Noel.
SPENCER, James William.
SPENCER, Michael.
STEWART, Robert Michael.
SYMONDS, Frederick Walter.
TAYLOR, James Rodney.
TAYLOR-CUMMINGS, Denis Edward.
THOMAS, Kalathur Varkey, B.SC. (ENG.).
THUNDER, Patrick Anthony.
TILDSLEY, Derek John.
TIPPETT, Graham Richard.
TOMSON, Donald.
TOPPING, Trevor Rex.
TOWLE, Alan Leslie.
TRACEY, Gordon Edgar.
TRAGAKIS, Demetrius George.
TRICKETT, Terrance.
WALSHAW, Michael Harland.
WALTERS, David Graham.
WALWYN, Timothy Christopher Lingard.
WARNER, John Whiten.
WATT, Alan Vallack.
WHITE, Lawrence Marcel.
WILLIAMS, Thomas.
WILLIAMSON, Ronald Trevor.
WOOD, John Peard Thornton.
WRIGHT, Lionel Glyn.
WYKE, Cyril Brian.
ZAKARIA, Hisham.
ZIMAN, Geoffrey Charles, B.A.

TRANSFERS

Student to Graduate

ADAMS, Alistair Grant, B.SC.
BANKS, Derek, B.ENG.
BARRETT, James William.
BRADFORD, Brian Francis.
BREEZE, John Valentine.
BROWNING, John Alexander.
BUTTON, Kenneth Victor, B.SC. (ENG.).
CHAKRABARTI, Manilal.
CHEW, James Robert, B.SC.(ENG.).
CLAXTON, Ronald James, B.SC. (ENG.).
CLINTON, Ian Ross, B.SC.
COMERFORD, Peter James, B.SC.
COWAN, Claude Isaac, B.SC.
CRAIGIE, Robert Isbister.
DALE, Edward David.
DAVIES, John Hugh, B.SC.
DAVIS, George.
DIFFLEY, John Alan.
DWIVEDI, Parmatma Prasad.
EDWARDS, Sub-Lt. John Christopher, B.SC.(ENG.), R.N.
ELKINGTON, Christopher.
EVANS, William Roger.
FISHER, Jack Edward.
FLACK, Michael Millward.
FURSLAND, Albert Raymond.
GEARY, Robert Arthur, B.SC.(ENG.).
GRAY, Raymond Beresford.
HARRIES, Thomas Wynne.
HARROWER, Robert Murray, B.SC.
HART, Gerald William.
HEATH, Christopher Anthony.
HIBBERT, John.
HOUSDEN, Alan Charles Boutteil, B.SC.(ENG.).
HUNTINGFORD, John Raymond.
LEAK, Malcolm Saunders, B.SC.
MASSEY, Arthur Edward Bennett, B.SC.
McINTYRE, John Duncan, B.SC.
MAHADEVAN, Kumar.
MILLIGAN, Norman William, B.SC.TECH.
MORTON, Donald Frank.
MURRAY, David.
NICHOLLS, Noel Charles.
PARKER, Anthony Hugh.
QURESHI, Mohammad Zakariyya.
RICKWOOD, John, B.SC.(ENG.).
SAXENA, Rajendra Kumar.
SIDEBOTHAM, Eric, B.SC.TECH.
SILCOX, André Raymond.
STEPHEN, Douglas Alan, B.SC.
SUDAN, Ravindra Nath, B.A., PH.D.
SWAIN, Robert Gordon.
TANNAHILL, Andrew, B.SC.
TATA, Kersi Faramji.
THOMAS, Laurence David.
THURLOW, Anthony Lawrence.
TODD, Maurice, B.SC.
TUCKER, David Edward.
WALSH, Peter Alfred.
WARDLE, Wilfrid Dennis.
WATSON, Donald Raymond.
WILLIAMS, Goronwy.
WILLIS, Donald James.
WIX, Anthony Hilary James.
WOOD, KENNETH Ettery, B.SC.
WORTHINGTON, Derek.
YOUNG, Brian.

Forthcoming Events

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated.

* No advance information will be available.

MAY

17 *Thursday* — ANNUAL GENERAL MEETING *followed by*
SIR GORDON RUSSELL, C.B.E., M.C.
Lecture on **Appearance Design*** (At approximately 6.30 p.m.)

JUNE

15 *Friday* — Measurement and Control Section Visit to Cambridge and Ely

21 *Thursday* — Institution Conversazione at the Royal Festival Hall

25 *Monday to* 29 *Friday* — Summer Meeting in the Midlands

SEPTEMBER

6 *Thursday to* 9 *Sunday* — Supply Section Visit to Northern Ireland

British Nuclear Energy Conference: Forthcoming Programme

JULY

3 *Tuesday to* 6 *Friday* — A Conference on the Physics of Nuclear Reactors, sponsored by The Institute of Physics. For full particulars, see April *Journal*, p. 263.

NOVEMBER

22 *Thursday and* 23 *Friday* — A Symposium on the Calder Hall Nuclear Power Plant. This is designed to cover all the important features of the planning, design and construction of the plant. There will be five sessions: Introduction and General Design; Technical and Research Problems; Engineering Design; Light and Electrical Engineering; and Future Developments and Summary. About twenty papers will be presented. Further details will be published later.

Contents of the Current Issues of the *Proceedings*

DATE OF JOURNAL REVIEW OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (APRIL 1956)

See *Journal*, April 1956, page 266.

PART B. RADIO AND ELECTRONIC ENGINEERING (MAY 1956)

Written discussion on **An Introduction to some Technical Factors affecting Point-to-Point Radiocommunication Systems**

Special article to be published — CAPT. C. F. BOOTH, O.B.E., AND B. N. MACLARTY, O.B.E.
The New High-Frequency Transmitting Station at Rugby (PAPER No. 1903 R, OCTOBER 1955)

March 1956 — R. F. ROUS, B.SC.
Pulse-Time-Modulation Terminals for Music Transmission over Radio Links (PAPER No. 1900 R, SEPTEMBER 1955)

May 1956 — E. N. BRAMLEY, M.SC., PH.D.
Directional Observations on H.F. Transmissions over 2100 km (PAPER No. 2011 R)

May 1956 — P. N. BUTCHER, PH.D.
A New Treatment of Lossy Periodic Waveguides (PAPER No. 1969 R)

May 1956 — W. M. G. FERNANDO, B.SC.(ENG.), AND PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.)
An Investigation of the Properties of Radial Cylindrical Surface Waves launched over Flat Reactive Surfaces (PAPER No. 2009 R)

Not yet reviewed — J. M. C. DUKES, M.A.
An Investigation into some Fundamental Properties of Strip Transmission Lines with the Aid of an Electrolytic Tank (PAPER No. 1991 R)

Not yet reviewed — G. H. METSON, M.C., PH.D., M.SC., B.SC.(ENG.), AND D. J. SARGENT
Electron Bombardment of the Glass Envelope of a Receiving Valve (PAPER No. 2038 M)

May 1956 — J. R. G. TWISLETON, B.SC.
An X-Band Magnetron Q-Measuring Apparatus (PAPER No. 2037 R)

Discussion on **Transistor Power Amplifiers** before the Mersey and North Wales Centre

Discussion on **An 8-MeV Linear Accelerator for X-Ray Therapy** before the North-Eastern Radio and Measurement Group

April 1956 — A. NEMET, DR.SC.TECHN., AND W. F. COX, B.SC.
Intensification of the X-Ray Image in Industrial Radiology (PAPER No. 1881 U, JULY 1955)

March 1956 — S. S. CARLISLE, M.SC., AND G. W. ALDERTON, B.SC.
The Instrumentation of a 14-inch Experimental Rolling Mill (PAPER No. 1933 M, NOVEMBER 1955)

November 1955 — LT.-CMDR. F. R. J. SPEARMAN, R.N.(RETD.), J. J. GAIT, M.A., B.SC., A. V. HEMINGWAY, B.SC.(ENG.), AND R. W. HYNES, B.SC.
Tridac, a Large Analogue Computing Machine (PAPER No. 1899 M, OCTOBER 1955)

Discussion on **Some Half-Tone Charge Storage Tubes** before the Radio and Telecommunication Section

February 1956 — C. J. N. CANDY, PH.D.
The Specification of the Properties of the Thermistor as a Circuit Element in Very-Low-Frequency Systems (PAPER No. 1751 M, DECEMBER 1954)

February 1956 — **A Vector Method for Amplitude-Modulated Signals** (PAPER No. 1772 M, JANUARY 1955)

May 1956 — P. H. SOLLOM, O.S.B., B.SC., PH.D., AND J. BROWN, M.A., PH.D.
A Centimetre-Wave Parallel-Plate Spectrometer (PAPER No. 2008 R)

PART C. MONOGRAPHS (MARCH 1956)

See *Journal*, March 1956, page 206.

Local Honorary Treasurers of the Incorporated Benevolent Fund

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